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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 251

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER July 27, 1915.

# THE CALOSOMA BEETLE (CALOSOMA SYCOPHANTA) IN NEW ENGLAND

By

A. F. BURGESS, In Charge of Gipsy Moth and Brown-tail Moth Investigations, and C. W. COLLINS
Entomological Assistant

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THE CALOSOMA BEETLE (CALOSOMA SYCOPHANTA).

Upper left, eggs; lower left, adult beetle feeding on gipsy moth caterpillar; upper right, gipsy moth pupæ destroyed by Calosoma larvæ; center, Calosoma larva, ventral view; right center, Calosoma larva, dorsal view; lower right, Calosoma pupa in cavity in ground. (From Howard and Fiske.)

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## INTRODUCTION.

In the spring of 1905 an arrangement was made by the United States Department of Agriculture to cooperate with the State of Massachusetts in importing and establishing the natural enemies of the gipsy moth and the brown-tail moth. Dr. L. O. Howard, Chief of the Bureau of Entomology, supervised the work, and until December 1, 1911, this arrangement remained in force, the project being financed jointly by the Bureau of Entomology and the State of Massachusetts. Since 1912, owing to the fact that the scope of the work involved nearly all of the New England States, these projects have been carried on solely by the Bureau of Entomology.

One of the natural enemies of the gipsy moth, which has long been known in Europe as of prime importance, is a green beetle be-

NOTE.—The writers wish to acknowledge their obligation to the members of the staff at the Gipsy Moth Laboratory for securing data and carrying on many of the experiments which are only briefly alluded to in this publication. There is hardly a man who has been connected with the laboratory for the past seven years who has not assisted to a greater or less extent in obtaining information and securing some of the results already mentioned. So many have assisted in this work that it is impossible to name each individual, but the writers wish to express their appreciation to all those who have taken part in the work.

longing to the family Carabidæ, and known to science as *Calosoma sycophanta* L. (Pl. I.) This species was collected and shipped to Massachusetts, as a result of arrangements made by Dr. Howard with numerous European collectors of insects, more particularly with Miss Marie Rühl, of Zurich, Switzerland. Several other closely related species of Calosoma were collected and some of these were received in sufficient numbers to permit of colonies being liberated in woodland infested with the gipsy moth. Several species of the allied genus Carabus were obtained and similarly liberated.

Up to the present time the only species that is known to have maintained itself is *Calosoma sycophanta*, and this insect has increased so enormously as to become an effective enemy of the gipsy moth in this country.

Table I gives the number of live specimens of *Calosoma sycophanta* which have been imported from Europe. Sixty-seven per cent of these beetles were liberated in the field and the balance were used for experimental and reproduction work. All the beneficial results secured in the field have accrued from about 4,000 beetles noted in the table.

TABLE I.—*Number of living specimens of Calosoma sycophanta received from Europe.*

| Year. | Number received. | Year. | Number received. |
|---|---|---|---|
| 1905 | 1 | 1909 | 405 |
| 1906 | 693 | 1910 | 1,305 |
| 1907 | 967 | | |
| 1908 | 675 | Total | 4,046 |

## METHODS OF PACKING BEETLES FOR SHIPMENT.

Different plans covering the packing of these beetles for shipment were tested during the years above mentioned. The most satisfactory arrangement was to pack the beetles singly in small safety-match boxes which contained a quantity of wet sphagnum moss. These boxes were packed in a larger wooden box (fig. 1), the usual size being $7\frac{1}{4}$ by 4 by $2\frac{1}{4}$ inches. A shipping label was glued to the box. Material packed in this manner was shipped by mail and received in good condition. Experience has shown that the greatest cause of mortality in shipping these beetles is due to lack of moisture. When sufficient moisture is provided no difficulty is experienced, and it is not necessary to place food of any kind in the boxes. As a rule, these shipments were en route from 10 to 12 days. In case beetles are to be forwarded and will not be in transit more than 2 days, several can be placed in a box and shipped by ordinary mail with very little injury resulting.

## NATIVE HOME OF CALOSOMA SYCOPHANTA AND HOSTS ATTACKED.

This insect is known to occur in France, Germany, Switzerland, Italy, and other European countries, being particularly abundant in cases where there are unusual outbreaks of destructive caterpillars. Its good work is mentioned in a number of European writings, and it is known to prey extensively on the gipsy moth (*Porthetria dispar* L.) and the pine sawfly (*Lophyrus pini* L.). As early as 1736 Reaumur published a general account of the life history of the species, and valuable information has been published by M. G. de la Pouge concerning his investigations of the larvæ of this insect.

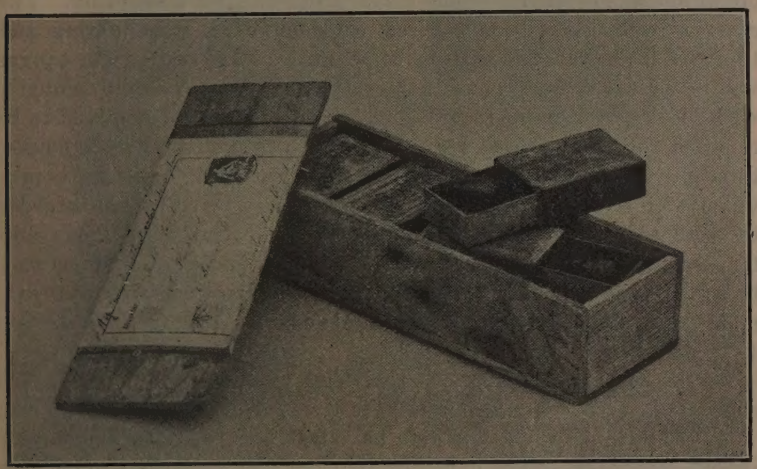


FIG. 1.—Shipping box, with cover removed to show method of packing Calosoma beetles. Each match box contains a single beetle and a small quantity of wet sphagnum moss. (From Burgess.)

## INVESTIGATIONAL WORK ON CALOSOMA SYCOPHANTA.

The year 1906 was the first in which these beetles were received in large enough numbers that colonies might be liberated or a study made of their habits. During that year considerable work was carried on by Mr. E. S. G. Titus and Mr. F. H. Mosher, and notes and observations on the behavior of the species in large breeding cages were made by Mr R. L. Webster. During the following summer the work was placed in charge of the senior author, and since that time detailed experiments have been conducted. Mr. C. W. Collins has assisted with this work during the entire period and for the past two or three years has planned and executed many of the experiments.

## EQUIPMENT USED FOR REARING PREDACEOUS BEETLES.

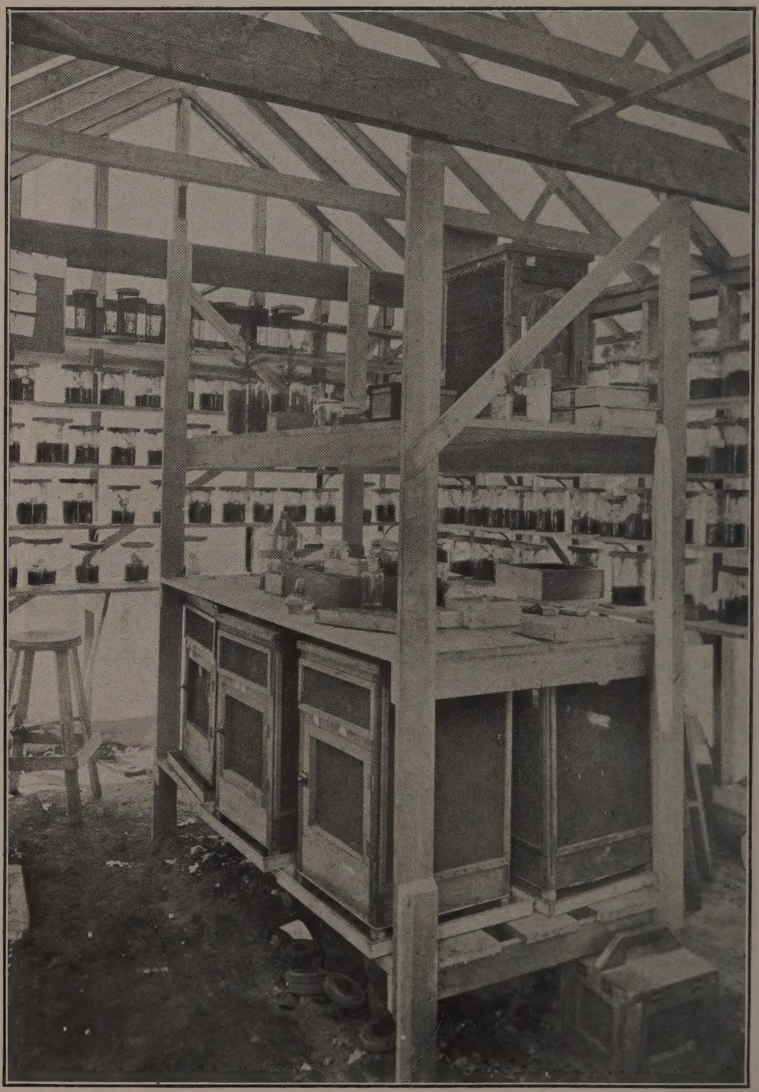
Experiments have shown that Calosoma beetles, in common with most other insects, thrive when they are kept under natural conditions. Fair success may be secured through rearing experiments in a laboratory, but as the beetles are most active, both concerning feeding and reproduction, during hot weather, and as it is important to regulate the soil moisture if best results are to be secured, it has been found decidedly advantageous to use an outdoor insectary for work of this description. An insectary such as is in use at the Gipsy Moth Laboratory, Melrose Highlands, Mass. (Pl. II), is inexpensive and will last a number of years. We have used a cement foundation on which was erected a frame constructed of 2 by 4 studding. The exterior walls have been covered with fine-mesh wire netting and the roof is canvas. A coating of white lead applied to the canvas will make it last longer, and if the netting walls are painted annually with black screen paint to prevent corrosion, they will not need to be renewed for two or three years. Copper-wire netting can be substituted for the walls and does not require paint. The insectary is provided with outside canvas curtains which may be rolled up in order to regulate the amount of sunlight or keep out rain; awnings could be used for this purpose if desired. Shelves, benches, or tables may be added as necessary. A building of this description fairly approximates outdoor conditions and has given very satisfactory service. (Pl. III.)

Beetles of this genus deposit their eggs in the ground. They also conceal themselves for a part of the time beneath litter or rubbish. The best results with *sycophanta* have been secured by using battery jars 8½ inches tall and 6½ inches in diameter (fig. 2), but a size slightly smaller will give as satisfactory results. Circular wooden tops are used to cover these jars, which are grooved to hold the top in place. A round hole, allowing air to pass into the jar, is cut in the center of the circular wooden top and is covered with wire netting. As *sycophanta* is a climbing species, but is unable to make its way up the smooth sides of the jars, a narrow strip of mosquito wire is attached to the inside of the top, so that it extends into the jar and gives the beetle an opportunity to climb to the top in search of caterpillars that are placed in the jar for food. About 3 inches of loam should be placed in each jar, and they are then ready for use

For rearing small larvæ of this species jelly tumblers containing earth and covered with cheesecloth can be used. The insects in this stage are cannibalistic, and it is therefore necessary to keep each larva in a separate jar if exact records are desired. Caterpillars or pupæ of almost any insect can be furnished for food and the soil must be kept slightly moist, but not wet. These larvæ can be reared

OUT-DOOR INSECTARIES FOR REARING CALOSOMA BEETLES.

*A* was built in 1909; *B* was built in 1910. (From Burgess.)



INTERIOR VIEW OF INSECTARY "*B*," SHOWN IN PLATE II. (FROM BURGESS.)

BOX CAGES USED FOR REARING CALOSOMA LARVÆ LATE IN THE SUMMER.

*B*, cover with fine-mesh screen, used in summer; *A*, showing coarse-mesh screen top, used after the larvæ have gone into the ground to transform and hibernate. (From Burgess.)

in wire cages if desired. The bottoms should be made of a circular piece of board 4 inches in diameter, having a hole in the center covered with netting. To the circumference of this base is tacked a strip of wire netting 10 inches in width. It should be cut long enough to lap at the side, so that it can be sewed with wire. The selvage edge of the wire netting should be used for the top of the cage and care should be taken that the circumference at the top and the bottom are the same. A cover similar to the ones used on the glass jars may then be placed on the top of the cage. These cages should be set 8 inches in the ground. After the larvæ become full grown they descend into the ground and form their pupal chambers. Cages of this

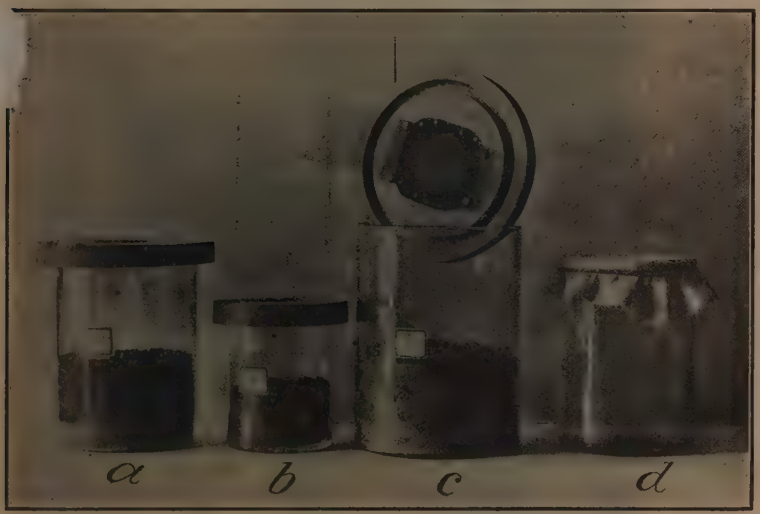



FIG. 2.—Jars for rearing Calosoma beetles: *a*, Large jar with wooden top and "ladder"; *b*, small jar with wooden top; *c*, showing construction of top and "ladder"; *d*, jar with cheesecloth top held in position with rubber band. (From Burgess.)

sort should not be disturbed until the following spring. For hibernating quarters for beetles, boxes with bottoms made of wire screen can be used (Pl. IV). They should be sunk into the ground from 18 to 20 inches, the earth inside the box being the same level as that on the outside. A hinged cover provided with wire netting should be placed on the top of the box and if convenient this cover should be padlocked so that the contents of the box will not be disturbed. Beetles may be placed in hibernation in cylinders (fig. 3) made of galvanized iron wire having a ¼-inch mesh. These can be constructed in the same manner as the small cylinders already mentioned. If larvæ are to be placed in these cylinders it will be necessary to line them with fine wire screen in order to prevent their escape. This

equipment has been selected as a result of many experiments and has been found to work very satisfactorily.

## METHODS OF REARING CALOSOMA BEETLE.

The most satisfactory manner of rearing these insects, in case it is desired to secure definite records of the number of eggs laid by a single individual or the amount of food consumed, is to place a pair

FIG. 3.—Wire hibernation cage that has been removed from the earth. Arrow shows the cavity where a Calosoma beetle hibernated; enlargement shows this beetle in the cage. (From Burgess.)

of beetles in one of the larger glass jars with a supply of caterpillars for food. The jars should be cleaned daily and all wounded or dead caterpillars removed. If this is not done, considerable difficulty is likely to be experienced. The earth should be examined daily, and if eggs are found the beetles should be transferred to a fresh jar and the original one kept, so that a record can be made of the larvæ that hatch. The number of larvæ that hatch is taken as an index of the number of eggs deposited, since it is impracticable to remove the eggs from the earth to make an accurate count, as they are easily

injured in handling. Records of the time spent in the different larval stages or the amount of food consumed may be secured by feeding the newly hatched larvæ in individual jelly glasses, as has already been described. When the larvæ become nearly full-grown they should be transferred to a larger jar, and it is better to place them in a wire cage sunk in the ground, so that they may have an opportunity to pupate in the soil without being disturbed.

These methods of rearing beetles were followed out, and in the spring and summer of 1908 and 1909 nearly 15,000 larvæ were reared and colonized in the field. Since that time it has been possible to collect both beetles and larvæ in the field, and the laboratory rearings for colonization have been discontinued.

## LIFE HISTORY OF CALOSOMA SYCOPHANTA.

Contrary to general belief, the adults of this species live two or three years and sometimes four. This information has been secured by careful study of the habits of the insect carried out over a long period.

### THE EGG (PL. I).

The egg is about 5.2 mm. long and 2.4 mm. wide, elliptical, tapering somewhat toward one end. It is white, with a faint yellowish tinge. The eggs are deposited in the ground by the females and hatch in from 3 to 10 days, depending upon the temperature. Careful experiments show that the time spent in the egg stage averages about 5.2 days in June and 4.4 days in July. Experiments have been tried to see whether or not hatching could be retarded by placing eggs in cold storage. In cases where they were exposed to freezing temperatures they shriveled and no hatching resulted.

### THE LARVA (PL. I).

The larvæ on hatching are nearly white. They remain in the cavity occupied by the egg and gradually grow darker until they become jet black. They then make their way to the surface of the ground and begin searching for food. They attack caterpillars or pupæ with little regard to the size, cut through the body wall of their prey with their sharp mandibles, and feed on the liquids and soft tissues within. They molt twice before becoming full grown. These larvæ climb trees that are provided with rough bark and search for caterpillars or pupæ concealed in crevices. Molting frequently takes place on the tree trunk, so that the cast skins of the larvæ are frequently found on trees where they have been feeding. The full-grown larvæ average about 25.8 mm. in length and 5.7 mm. in width. The body is shining black, while the mandibles, legs, mouthparts, antennæ, and lateral and ventral abdominal markings are

dark brown; the dorsum of the last abdominal segment is chestnut-brown. The two caudal appendages forming a part of the last abdominal segment are short and quite erect, and are provided with a large, stout, dorsal tooth and a smaller lateral tooth, both of which bear spines. Length of time in the larval stage varies with the temperature and food supply. The following record of 12 larvæ which hatched June 20, 1908, shows the time spent in active feeding:

| | Days. |
|---|---|
| First larval stage | 2 |
| Second larval stage | 3 |
| Third larval stage | 9 |
| Total | 14 |

The weather during this period was warm and the food supply was ample. The time when larvæ are found in the field is governed largely by weather conditions in the spring, but ranges from June 25 to the middle of August.

### DISTANCE TRAVELED BY LARVÆ.

As has already been stated, the larvæ of the species are capable of climbing trees, and this makes it possible for them to feed on caterpillars or pupæ that may be present on the trunks or large branches. In some cases molted skins of the larvæ have been found in large trees at a height of 50 feet above the ground.

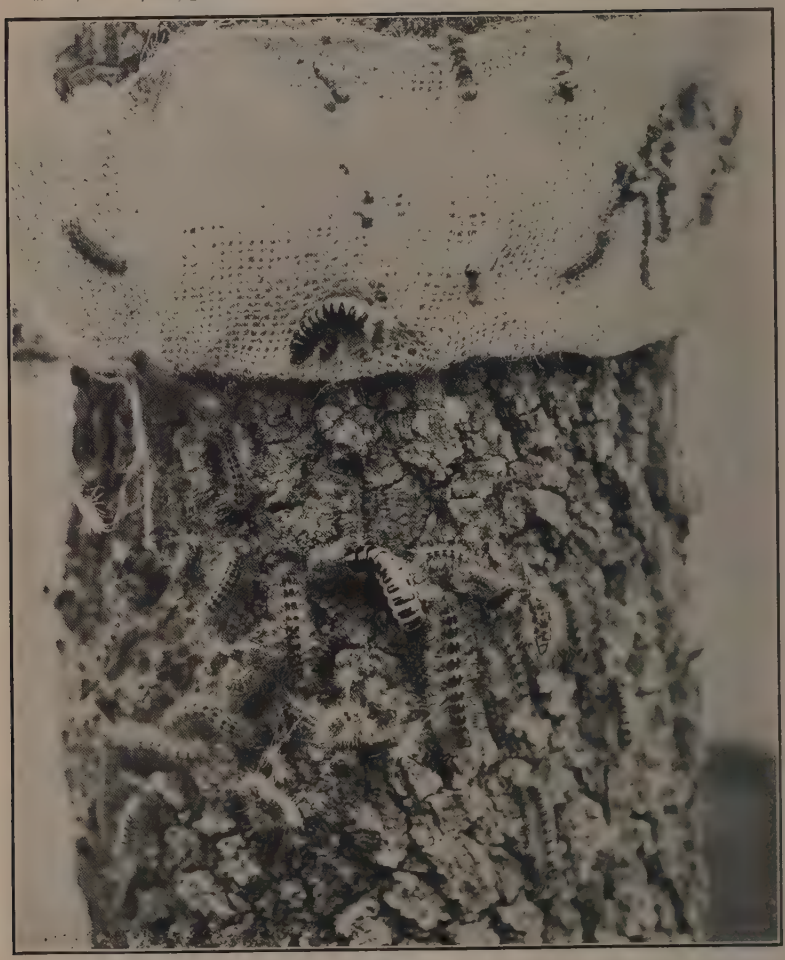
An experiment was carried on in 1910 to determine the distance that a newly hatched larva would travel if no food was supplied. The experiment started at 8.30 a. m., July 13, and continued uninterruptedly for 72 hours. Apparatus was constructed to measure accurately the distance traveled by this individual, which totaled 9,058 feet, or 1.78 miles. The weather was very hot during the time the experiment was carried on, and neither moisture nor food was supplied.

### FEEDING HABITS OF LARVÆ.

The larvæ feed both by day and by night, and are more active when the weather is hot. As a rule, caterpillars are attacked from the side or from beneath, and if the specimens are hairy the favored place seems to be between the segments, where the larvæ can more readily pierce the integument with their sharp mandibles. Newly hatched *sycophanta* larvæ are able successfully to combat practically all caterpillars, regardless of size. Many specimens are injured to such an extent that they evidently die, and thus more caterpillars are prevented from transforming than are actually eaten. The pupæ of lepidopterons, especially those that are not provided with a cocoon, are particularly susceptible to attack by the Calosoma larvæ.

PUPÆ OF THE GIPSY MOTH THAT HAVE BEEN DESTROYED BY THE LARVÆ OF CALOSOMA SYCOPHANTA.

Note the irregular holes, which are characteristic. (From Burgess.)



LARVÆ OF CALOSOMA SYCOPHANTA FEEDING ON GIPSY MOTH CATERPILLARS UNDER BURLAP.

Photograph taken at Pine Bank Park, Malden, Mass., 1910. (From Burgess.)

The larvæ usually cut a hole between the segments of the pupæ (Pl. V), and after feeding begins the hole is gradually enlarged until the front portion of the body finds entrance to the pupa. The internal contents in most cases is completely devoured before the larva leaves the pupa to search for other food. The holes are always irregular in outline and can be easily distinguished from the exit holes of parasites. Gipsy-moth pupæ massed on the trunks of trees, underneath branches, or below burlap bands (Pl. VI) are favored locations as feeding grounds for Calosoma larvæ. In many towns in the infested gipsy-moth district one or more Calosoma larvæ can usually be found in each mass of gipsy-moth pupæ examined. These predaceous larvæ occasionally attack female moths, and several cases have been noted where the latter have been killed before they had an opportunity to deposit eggs.

*Sycophanta* larvæ feed freely on any lepidopterous larvæ or pupæ which they may find. A considerable number of cases have been noted where the larvæ have cut through the cocoons of the American tent caterpillar (*Malacosoma americana* Fab.) and forest tent caterpillar (*Malacosoma disstria* Hübw.) and have destroyed the pupæ within.

The life history of the Calosoma beetle is well adapted to that of the gipsy moth. The beetles are present and active during the time of year when gipsy-moth caterpillars are abundant and the larvæ are active and feeding while the gipsy moth is still in the pupal stage. No other common lepidopterous species which occurs in New England is so well adapted as a host of this beetle as the gipsy moth, and although large numbers of other caterpillars and pupæ are destroyed annually, the increase of the beetle is not as satisfactory in regions where the gipsy moth is not available for food.

In the summer of 1908 several series of experiments were conducted to determine the number of sixth-stage gipsy-moth caterpillars destroyed by the larvæ of *C. sycophanta*. It was found that on the average a single larva of this beetle would kill 41 full-grown caterpillars between the time of hatching and pupation. If smaller larvæ were attacked, a greater number would, of course, be destroyed. It is safe to say that 50 or more caterpillars would be necessary to satisfy the appetite of a Calosoma larva under field conditions. Most of the *sycophanta* larvæ hatch at a time when more gipsy-moth pupæ than caterpillars are available for food. Experiments show that on the average about 13 female pupæ are destroyed by each larva when fed in captivity. Observations in the field and jar experiments both indicate that a greater percentage of females than males is destroyed by the Calosoma larvæ, the average ratio being 75 per cent females to 50 per cent males.

### EFFECT OF "WILT" ON CALOSOMA LARVÆ.

In the area infested by the gipsy moth a disease known as "wilt" is quite prevalent among caterpillars. A number of experiments have been conducted to determine whether *sycophanta* larvæ, if they were obliged to feed on caterpillars affected by this disease, would contract it and die. The experiments were conducted in 1910 and *sycophanta* larvæ were fed on diseased caterpillars in breeding jars. The results showed that the larvæ of this beetle suffer little if any from wilt. A few died, but no greater number than was the case in check experiments where healthy food was supplied. Only a single case has been noted in the field where Calosoma larvæ had apparently died from wilt, and as the specimens were not examined microscopically, death may not have been due to this cause. Beetle larvæ are so commonly found in masses of gipsy-moth pupæ and caterpillars which are dead or dying from wilt that if the beetle larvæ were susceptible to it, large numbers of dead specimens would be found.

### EFFECT OF SPRAYING ON CALOSOMA LARVÆ.

The question has been repeatedly asked whether or not the spraying of infested areas would result in destroying the beetles or their larvæ on account of the belief that many of them would feed on poisoned caterpillars. Laboratory experiments, where caterpillars were taken from sprayed trees and used as food for beetle larvæ, show that the death rate was no greater than normal, while observations in the field have failed to reveal any case where the beetles or larvæ fed upon dead caterpillars or those in a dying condition from feeding on poisoned foliage. Apparently the beetles migrate in the field to locations where food is abundant. If eggs have been deposited in sprayed areas so that larvæ are abundant, little doubt remains that some of them may fail to secure food and die from starvation. No direct evidence is available to indicate that either the beetle or the larva is killed as a result of spraying, and we have always recommended that spraying should not be discontinued in cases of gross infestation in order to protect the beetles. The enormous increase of Calosoma seems to indicate that a discontinuance of spraying is not necessary.

### STARVATION EXPERIMENTS WITH CALOSOMA LARVÆ.

Inasmuch as the ability of Calosoma larvæ to develop depends upon whether sufficient food can be found, a series of experiments was carried on in 1908 to determine how long they would survive in the different stages if no food was supplied. The larvæ were placed in jars containing a small amount of earth and no food was furnished.

The results showed that first-stage larvæ would live 3.56 days, second stage 6 to 9 days, and third stage 8 to 16 days before dying from starvation. This information, together with data secured on the distance which first-stage larvæ can crawl, indicates that the species is able to withstand adverse conditions and still survive.

### PUPATION OF CALOSOMA LARVÆ.

Several attempts have been made to induce the larvæ to hibernate during the winter. A number of lots were placed in cold storage and several other experiments were conducted by placing the larvæ in jars of earth in a cold cellar. In every case, however, either the larvæ had transformed to pupæ, which had died, or to adults, when the jars were examined in the spring. After becoming full grown the larvæ entered the ground, formed a chamber, and entered the pupal stage. The depth to which the larvæ descend depends upon the condition of the soil. Occasionally pupæ of this bettle are found beneath boards or rocks, but in many cases they descend from 6 to 10 inches in loose soil before making the pupal chamber. In any event, pupation takes place above the frost line. After burrowing into the ground and forming a pupal chamber the body of the larva shortens, and after resting it transforms to pupa. The period from the time the larva stops feeding until pupation occurs averages about 10 days.

### THE PUPA (PL. I).

The pupa of *Calosoma sycophanta* is pale yellow, about 25 mm. long and 12 mm. in width at the first abdominal segment. The mouthparts, antennæ, wings, and legs are folded beneath the head, the hind legs extending to the tip of the abdomen and the wings extending beyond the fourth abdominal segment.

Many experiments have been conducted in removing pupæ of this species from the cavities in which they pupated, but in most cases it is impossible to do this without causing injury and preventing normal emergence of the adult. In rearing this beetle care should be taken not to disturb the larva after it begins to form its pupal chamber, otherwise either a poor emergence of beetles or a considerable number of crippled specimens is likely to result. If definite records are desired regarding individual specimens, the larvæ should be allowed to pupate in wire cages in the ground. In case it is desired to rear through a large number of specimens without reference to definite records, a large number of larvæ can be placed periodically in one of the box cages previously mentioned. The time spent in the pupal stage averages about 13 days, and after the adults emerge they remain in the cavity which held the pupæ throughout the winter and do not ordinarily come to the surface of the ground until June 1

of the following spring. Many experiments have been tried in an attempt to force early emergence and with an idea of breeding this species during the winter in the laboratory, in order to increase the supply for liberation in the field. Efforts along this line have been futile. The species seems to have a well-fixed habit of winter hibernation, and apparently requires a long resting period. It is difficult to secure proper food for beetles that may be taken from hiberation during the winter, but, even if this could be obtained, no satisfactory way has been found to increase the number of broods annually.

### THE ADULT OR BEETLE.

As has been previously stated, the beetles emerge about the first of June. The exact time varies slightly from year to year, depending upon the weather conditions. Beetle larvæ that transformed to pupæ and remained as beetles in the pupal cavities during the winter emerge at this time as well as other beetles that developed from larvæ in previous years. In July after the adults have finished feeding they burrow into the ground and form a cavity in which they remain the next winter. The distance beneath the surface varies greatly and depends to some extent on the looseness of the soil which they enter. They seldom go below the frost line, and, this being the case, the earth around them is usually frozen solid during the winter. The males and females enter hibernation about the same time, but the former usually emerge a day or two earlier in the spring. A few cases are on record where beetles have remained dormant in the ground continuously for nearly two years. In one instance a pair of beetles entered hibernation on July 28, 1910, and did not emerge from the ground until June, 1912. Several cases of this sort have been found as a result of careful notes from breeding experiments kept at the laboratory. In every case where this has occurred the beetles concerned were more than a year old. In no case have beetles failed to emerge the spring following their development from the larvæ. In connection with the hibernation of this species, it should be said that the beetles habitually live in that stage more than one year. As a rule they live for two years and several records indicate that it is not uncommon for them to remain in the beetle stage for three years. A record of one experiment shows that several females lived more than four years. Records kept at the laboratory indicate that the percentage of mortality during hibernation is rather high. It should be remembered that these beetles were placed in hibernating cages in the laboratory yard, and although here natural conditions are approximated as nearly as is possible, the location was not quite as suitable as if the insects had had an opportunity to make their own selection. In our experiments

the mortality of beetles during the winter runs from 22 to 35 per cent, first-year beetles showing the lowest death rate.

A large number of experiments were carried on in the spring of 1908 to determine whether it would be possible to induce this species to develop more than one brood in a single year. Beetles were removed from hibernation on March 4 and were fed in jars at the laboratory. Difficulty was experienced in securing a sufficient food supply, but the beetles did not feed at all freely and were rather inactive in the jars. Eggs were deposited a little earlier in the season than was the case when the species emerged normally, but the larvæ grew very slowly and did not develop much earlier than those which resulted from beetles that emerged early in June. The experiment indicated very conclusively that it was not possible to force this species and that the habit of developing a single generation a year is firmly fixed.

### FEEDING HABITS OF ADULTS.

The beetles climb trees readily and travel out on the branches and sometimes cling to the leaves while searching for caterpillars. If disturbed they usually fall to the ground and immediately seek shelter underneath leaves or rubbish. The beetles usually seize the caterpillars in the middle of the back and cut through the body wall with their sharp mandibles. They feed upon the liquids and fatty material which form the body content of the caterpillar and usually injure many more than they actually devour. The average length of time during which the beetles feed is from about June 1 to July 15. From records secured in 1910 the shortest period of feeding was 32 days and the longest 66 days, with an average of 50 days. These records were secured from beetles kept in captivity. It will be noted that the time when the beetles are feeding corresponds roughly with the time when the gipsy moth is in the larval stage. This makes this beetle particularly adapted for feeding on the gipsy moth, and a further advantage results from the fact that the larvæ of *Calosoma sycophanta* are most active during the time the gipsy moth is in the pupal stage. The food of the adults is very similar to that of the larvæ; both are frequently found in the field feeding upon larvæ and pupæ of native Lepidoptera.

It is difficult to determine the number of caterpillars which are destroyed by a single beetle. This can only be done by feeding the beetles in captivity; and under these conditions they evidently do not destroy as many caterpillars as they would if they were living in the open. Experiments which have been conducted, using full-grown tent caterpillars and gipsy-moth caterpillars, showed that the average number of caterpillars destroyed by an old beetle was 328 and by young beetles 239. The young beetles—that is, those that are feeding

for the first year—do not eat nearly as many caterpillars as beetles that are older. On the other hand, the younger beetles seldom deposit eggs, while the older ones are very prolific.

Experiments conducted with small brown-tail moth caterpillars indicate that a much larger number of this species was destroyed. This is undoubtedly due to the small size of the caterpillars, and similar results would probably be secured if small gipsy-moth caterpillars were used for food.

In some of the laboratory experiments beef was offered to the beetles for food. They fed upon it to some extent for a short time, but after a week they refused to eat. Apparently they do not care for this substance if caterpillars are available.

### EXPERIMENTS IN FEEDING BEETLES ON CATERPILLARS INFECTED BY WILT.

Several experiments have been conducted in feeding *sycophanta* beetles upon gipsy-moth caterpillars infected with the bacterial disease known as "wilt." Experiments were started in July, 1907, a single pair of beetles being fed from July 23 to August 14 with caterpillars which showed pronounced symptoms of the disease. Twenty-one larvæ were eaten, three were so badly injured that they died, and the remaining larvæ supplied to the beetles in the jar died from disease. These beetles ate slightly less than another pair that were fed on healthy caterpillars. Both pairs entered hibernation and those that were furnished diseased caterpillars showed no ill effects. Several similar experiments have been conducted since that time, and the results indicate that these beetles are not susceptible to the "wilt." Each year large numbers of gipsy-moth caterpillars die from the disease in jars where Calosoma beetles are confined for experiments, and if it was seriously destructive to the beetles or their larvæ the fact would have been determined by heavy mortality among them.

### EFFECT OF SPRAYING ON BEETLES.

Several attempts have been made to determine whether Calosoma beetles are injured or killed by feeding on gipsy-moth caterpillars taken from sprayed trees. In 1910 a small area of brush growth near the laboratory was sprayed with arsenate of lead, and gipsy-moth caterpillars collected from time to time were furnished the beetles for food. Check experiments were also run in unsprayed areas. The experiment failed to show that any of the beetles were injured by feeding on caterpillars taken from sprayed foliage. Several colonies of beetles have been liberated in woodland that has been heavily sprayed, and not infrequently beetles are found on street or park trees which have been sprayed with arsenate of lead. Dead beetles or their larvæ are found very rarely, and thus it is evident

that no wholesale injury to the species is caused by their feeding on poisoned caterpillars.

STARVATION EXPERIMENTS.

In 1910 experiments were conducted to determine the length of time that these beetles could survive without food. For this purpose two pairs of young beetles and two pairs of old beetles were placed in jars of earth in one of the cages in the laboratory yard. The results of the experiment are shown in Table II:

TABLE II.—*Starvation experiment to determine the length of time adult Calosoma sycophanta can live without food.*

| Calosoma sycophanta. | Date emerged from hibernation. | Date male died. | Length of time male lived without food. | Date female died. | Length of time female lived without food. |
|---|---|---|---|---|---|
| | 1910. | 1910. | | 1910. | |
| Young pair | May 26 | June 26 | 1 month | July 9 | 1 month 13 days. |
| Do | do | June 29 | 1 month 3 days | July 5 | 1 month 9 days. |
| Old pair | do | July 17 | 1 month 21 days | June 26 | 1 month. |
| Do | do | June 30 | 1 month 4 days | (1) | 1 month 21 days.[1] |

[1] This female, after living without food for 1 month and 21 days, was offered several full-grown gipsy-moth caterpillars July 17 and ate two in 10 minutes. The next day a male was added and copulation was attempted several times, but without satisfactory results. The female died July 30 without depositing eggs. During the 12 days the pair were in the jar 33 sixth-stage gipsy-moth caterpillars were eaten.

This experiment shows that beetles of this species can live during the summer for a month or more without food. Old beetles appear to withstand starvation better than young beetles, and males die sooner than females. In 1907 a field colony of beetles was liberated in order to test their ability to survive where the food supply was very limited. Fifty specimens, 25 of each sex, were liberated in woodland at Peabody, Mass., August 28. The beetles were received from Europe early in the month and had been supplied with very little food after their arrival. At the time they were liberated there were no gipsy-moth caterpillars in the field and very few pupæ. An occasional native caterpillar could be found, but they were rare in the vicinity of the colony. Several examinations were made the following spring and summer. On July 8 Calosoma larvæ were found, showing that the species had survived and that reproduction had taken place. This indicates that the beetles are able to survive under very unfavorable conditions.

In order to determine how far male beetles might be attracted by females, several experiments were conducted, but negative results were secured.

REPRODUCTION.

After emerging from hibernation and feeding for a few days, copulation takes place and eggs are deposited by the females. It is neces-

sary for the latter to mate several times during the season, or a large percentage of infertile eggs will be laid. Old beetles lay many more eggs than young beetles. The highest number of eggs laid by a single female in a season was 653. If an average is taken covering all the beetles under observation for a single year, both young and old, the rate of increase—that is, the average number of eggs deposited by each female—will be about 100. The result of several years' work in rearing beetles in confinement indicates that it is a common habit of this species to oviposit sparingly, if at all, the first summer, and to lay eggs freely the second season. If conditions are favorable the first year, a number of eggs may be laid, while if they are unfavorable oviposition is postponed until the second or third summer, as the case may be. It sometimes happens that eggs are laid the first and third summers, but not during the second; at any rate, each female will lay about an equal number of eggs, but the time they are deposited varies greatly.

The data secured from field colonies indicates that the same conditions apply. Two-thirds of the localities that were colonized with beetle larvæ have shown some reproduction the year following planting, while colonies where adults were liberated usually show much larger increase. The jar records indicate that the old beetles multiply seven times as fast as the young ones, and in the field, based on the number of molt skins found in several colonies, the average is 10 to 1 in favor of the old beetles.

### HABITS OF FLIGHT.

For a number of years it was believed that these beetles did not fly. They were frequently seen in trees, and when disturbed would fall to the ground without making any effort to use their wings. A number of observations, however, prove that the species flies quite freely, particularly early in the spring. There is at that time considerable migration of the adults after they emerge from hibernation, and they undoubtedly seek localities where food is plentiful. The fact that beetles have been found more than 20 miles outside the area where they were colonized indicates that spread is accomplished by flying or that the species was carried on vehicles or in some other way.

### ATTRACTION OF ADULTS TO LIGHT.

Several native species of Calosoma are attracted to strong light. Although many observations have been made in eastern Massachusetts, where *sycophanta* was first colonized, and where the species is abundant, it has never been taken at arc lights, and we have received no record to that effect from various collectors in this vicinity. Several specimens are reported to have been taken at electric lights

EXCREMENT OF SKUNK COLLECTED IN THE FIELD, SHOWING MANY FRAGMENTS OF ADULTS OF CALOSOMA SYCOPHANTA. (ORIGINAL.)

at Salisbury Beach, Salisbury, Mass., in 1913. It is probable that the species is occasionally attracted to lights, but it is apparent that this beetle does not frequent lights as commonly as other species of the same genus.

EXPERIMENTS IN DROWNING BEETLES.

Early in the spring of 1910 a number of experiments were conducted to determine whether beetles could continue to live after being submerged in water for any length of time. This information was quite desirable, inasmuch as areas where the beetles hibernate during the winter might in the spring be covered with water for a considerable period, so that unless the species are able to withstand submergence many specimens might be destroyed in this way.

March 17, 1910, cages containing frozen earth were dug up and two male beetles were removed from their cavities and put in a jar of water. At 11 a. m. the jar was placed in the laboratory ice chest and kept at a temperature of 39° F. Some pieces of cloth and two small blocks of wood were put in the jar with the intention of keeping the beetles submerged, but at 5.58 p. m., when an examination was made, both beetles were found swimming about in the water. They were again submerged by placing a quantity of blotting paper inside of the jar, but on the following morning they had succeeded in making their way to the surface. A wooden float was then constructed which was placed in the jar in such a manner as to keep the insects under water. They were kept in this position four days, although every 12 hours they were taken out and examined to see if they showed signs of life. At the end of this period they were removed, apparently dead, but in less than an hour they revived sufficiently to begin feeding on cutworms.

This experiment shows that beetles of this species can live for at least four days, and probably longer, if submerged in water a few degrees above the freezing point.

March 17, 1910, several small wire cages, used for feeding larvæ, each of which contained a newly formed beetle, were dug up and submerged in a tub of water to see if the insects would survive this treatment. There were several inches of frost on the top of each cage and the temperature of the water was about 39° F. March 18, at 8 a. m., one female had emerged and was clinging to the wire just above the water. An examination of the earth in this cage showed that the hibernation cavity was about 6 inches deep, and as soon as it thawed out the insect made its way to the surface of the water.

Another cage was examined after it had been submerged 24 hours and a living beetle was found 3½ inches below the surface of the earth. The cage was replaced and removed later in the day and it was found that the beetle had worked its way to a point a half inch

below the surface of the earth. It appeared dead, but on removal soon revived.

At the end of 48 hours another cage was examined, and a live beetle found 3½ inches below the surface of the earth. This cage was replaced and on the following morning, after it had been submerged for 2½ days, the beetle was found on the surface of the water.

The last cage was opened at the end of four days, and an active female was found in the earth, which was now very compact. The beetle was replaced in the mud and the cage submerged, but at 3.10 p. m. it came to the surface of the water, after having remained beneath it four days and two hours.

These experiments indicate that this species is able to withstand excessive amounts of moisture and that in the spring, when lowlands are flooded, the majority of the insects will survive, apparently without serious inconvenience.

On March 21 a female Calosoma beetle that had been submerged for four days and two hours was placed in a tub of water and floated about on the surface. It seemed desirable to ascertain how long the insect would remain alive and float when the temperature of the water was maintained at about 39° F., and also whether it was able to make any progress in swimming. During the first hour and fifteen minutes the insect swam a distance of 22 inches. It rested on the water very easily, less than one-half of the body being submerged. The legs moved continually, but its progress was very slow. This beetle remained in the tub of water 15 days and at the end of that period was removed for dead. In a few hours it revived and began feeding, and was used later in the summer in rearing experiments. This shows that in the spring beetles of this species might survive several days if they should fall into ponds, and that they would probably float with the current and might be distributed quite a long distance in this way, especially if they fell into streams or rivers.

## NATURAL ENEMIES.

It is undoubtedly true that this species is eaten to some extent by birds, and the hairy woodpecker has been charged with destroying it on several occasions. The crow has been observed to feed on the beetles and also to carry them to their nests which were occupied by young birds. Among the other vertebrate enemies may be mentioned skunks, raccoons, and foxes. The last two mentioned, when kept in captivity, will feed on these beetles very freely. Abundant evidence has been secured that skunks destroy large numbers of the beetles. In some sections where these insects were very abundant it was found that the remains of the beetles formed the chief constituent of the excrement of this animal. (Pl. VII.) Not only do the skunks secure beetles which may be on the ground, but they

undoubtedly obtain many that have just transformed to the beetle stage and are just beneath the surface. In several places, where beetles were numerous and were doing good work in destroying gipsy-moth caterpillars, it was found later in the season that the ground beneath the trees had been uprooted to a considerable extent and skunk droppings containing large numbers of beetle remains were abundant in the locality.

These beetles are also attacked by a tachinid fly, probably *Viviania georgiae*, as a few specimens of this species have been reared from beetles which died after they had been brought in from the field.

Under laboratory conditions the beetles and their larvæ are sometimes seriously attacked by a mite known as *Tyroglyphus armipes* Bks. It is improbable that they suffer from this enemy under field conditions, but unless breeding jars are kept free from dead caterpillars, considerable difficulty is likely to result in rearing the insect in confinement.

## COLONIZATION OF CALOSOMA SYCOPHANTA.

Colonies of this species were first liberated in the field in 1906 in the towns of Saugus, Malden, Winchester, Burlington, and Lynnfield, Mass. Other colonies have been released since that time in territory where the insect did not occur and where gipsy-moth infestation was severe. There have been liberated in the field about 2,700 beetles which were imported from Europe; in addition to this, during the first two or three years following 1907, colonies of larvæ and some beetles reared at the laboratory were also released in the field. Since 1910 this species has not been received from Europe, and most of the specimens colonized have been collected in eastern Massachusetts, where the beetles have become abundant. Table III gives a summary of the number of beetles imported, as well as those collected and colonized since the work began.

TABLE III.—*Number of living Calosoma sycophanta imported, and number of beetles and larvæ colonized.*

| Year. | Received. | Colonized from importations. | Colonized from rearings and field collections. | |
|---|---|---|---|---|
| | | | Adults. | Larvæ. |
| 1906 | 693 | 389 | | |
| 1907 | 967 | 578 | | |
| 1908 | 675 | 430 | | 2,300 |
| 1909 | 405 | 250 | | 6,100 |
| 1910 | 1,305 | 1,064 | 452 | 6,380 |
| 1911 | | | 621 | 1,104 |
| 1912 | | | 176 | |
| 1913 | | | 3,014 | 2,901 |
| 1914 | | | 4,244 | 330 |
| Total | 4,045 | 2,711 | 8,507 | 19,115 |

In addition to the beetles colonized, as given in Table III, 340 living specimens were shipped from the laboratory during 1912 and 1913. Most of these went to New Brunswick, Canada, where an infestation of the brown-tail moth exists, but a small lot was shipped to the commissioner of horticulture of California for colonization in that State, and another lot was forwarded to New Mexico, where a serious outbreak of the range caterpillar (*Hemileuca oliviae* Ckll.) exists.

In 1914, 1,830 specimens were collected by Mr. L. S. McLaine, an assistant of Dr. C. Gordon Hewitt, entomologist to the Dominion of Canada, and shipped to New Brunswick, and 1,700 were obtained by Mr. H. E. Smith and forwarded to New Mexico by arrangement with Prof. F. M. Webster, in charge of cereal and forage insect investigations in the Bureau of Entomology.[1]

## METHODS OF SECURING DATA FROM FIELD COLONIES.

In order to determine whether this species has increased in spread under natural conditions, a large amount of work has been carried on each year in the field. Owing to the large size of the beetle and its larvæ, it is comparatively easy to make observations on this species. For the first few years after liberations were made observations were carried on in the localities where the colonies were planted. The work was taken up about the 1st of July and continued as long as information could be secured in August. Effort was made to determine not only whether the species had survived, but to find out whether it was spreading. This work gave very gratifying results. On trees which were burlapped it was possible in many cases to find the beetles or their larvæ feeding on gipsy-moth larvæ or pupæ beneath the bands. The beetle larvæ feed extensively on gipsy-moth pupæ, and it is quite easy to determine if pupæ have been destroyed by this means, even though the insect may not be present. As the larvæ of *sycophanta* climb trees and feed among masses of pupæ, an examination of these masses in midsummer usually indicates whether the species is present. An additional help in this respect results from the fact that these beetle larvæ molt among the masses of pupæ on the trees, and unless there are heavy rains, which wash these molted skins to the ground, it is possible, for a period of several weeks after actual feeding took place, to determine whether the species has been present. Using this information as a guide, parties of men have been employed each year to examine infested places in the towns outside of localities in which colonization actually took place. In this way it has been possible to determine the spread of the insect from year to year

[1] Results of the introduction into New Mexico will be set forth in detail in a report on the range caterpillar investigation of this bureau.

# MAP
showing
DISPERSION OF THE CALOSOMA BEETLE
and
GIPSY MOTH IN NEW ENGLAND — 1914.

— 1911 = DISPERSION of C. SYCOPHANTA.
— 1912 = " " "
— 1913 = " " "
— 1914 = " " "

●= COLONIES LIBERATED-1914. X= RECOVERIES MADE - 1914.
▬ = GIPSY MOTH QUARANTINE LINE - 1914.

and to secure data on the abundance of the species and the effectiveness of its work.

The accompanying map (Pl. VIII) shows the territory infested with the gipsy moth in 1914; also the areas where the Calosoma beetle was found from the years 1910 to 1914, inclusive.

## DISPERSION OF CALOSOMA SYCOPHANTA.

Table IV shows the annual dispersion of *Calosoma sycophanta* since it was introduced into Massachusetts. This information has been secured by careful field examinations, and towns have not been included in the area unless the beetles or their larvæ have been found in several localities throughout the town.

TABLE IV.—*Table showing annual dispersion of Calosoma sycophanta in New England, 1909–1914.*

| Year. | Area. | Year. | Area. |
|---|---|---|---|
| | *Sq. m.* | | *Sq. m.* |
| 1909 | 9 | 1912 | 1,615 |
| 1910 | 106 | 1913 | 3,063 |
| 1911 | 425 | 1914 | 5,425 |

The statements which follow give a list of the towns and cities in Massachusetts, New Hampshire, Maine, Rhode Island, and Connecticut in which colonies of this species have been liberated, the number released, and the places where they have been found as a result of spread from nearby towns. The records are complete up to and including 1914, and the information is given somewhat in detail, so that it may be of value to owners of property or residents in the sections concerned.

### MASSACHUSETTS.

*Abington.*—No colonies were liberated in this town. Examinations of woodlands in 1914 resulted in finding traces of the beetles, although little damage was noted by the gipsy moth.

*Acton.*—In 1910 a colony of 200 larvæ was liberated in the western part of the town. During August, 1912, the larval molt skins were found in many woodlands throughout, and further evidences of the increase and efficiency of the species were reported in 1913 and 1914.

*Amesbury.*—In 1910 a colony of 200 larvæ was liberated in woodland off Haverhill Street. August, 1912, examinations showed them to be present in many localities throughout the town, and in 1913 and 1914 further reports indicated that they had become numerous in these sections.

*Andover.*—During 1910, 100 beetles were liberated in this town. In 1911 they were recovered in a few localities. They were recovered in 26 different localities in 1912. Additional data secured in 1913 and 1914 showed them to be present in large numbers throughout. These records are indicative that these beetles are common enough throughout this section to be accomplishing an appreciable amount of good as an enemy of the gipsy moth.

*Arlington.*—In 1910, 200 beetle larvæ were colonized. During 1911 they were recovered in various localities. No further examinations have been made, as the results indicated that this species was well established here.

*Ashburnham.*—In 1914, 87 beetles were colonized in a section where there was a heavy infestation of gipsy moths. Later reports show that the beetles had spread sparingly into other sections.

*Ashby.*—During 1914, 174 beetles were liberated in two localities where gipsy moths were abundant. They also made their appearance in other sections as a result of spread from other towns.

*Ashland.*—A colony of 100 beetles were liberated in 1913 at a locality where the gipsy-moth infestation was moderate. Later in the season this species was recovered at points distant from the colony. In 1914 it was universal throughout the town.

*Avon.*—No colonies were liberated here, but in 1913 recoveries were made in the southern part of the town, and a satisfactory increase was noted in 1914.

*Ayer.*—In 1913 beetles were recovered in three localities, although no colonies had been liberated. This species showed remarkable increase in 1914.

*Barnstable.*—No beetles were liberated in this town. In 1914 this species was reported as abundant in various localities.

*Barre.*—No colonies were liberated, but beetles were reported in 1914, which is a result of spread from other towns.

*Bedford.*—During 1910, 100 beetles were liberated. In 1911 this species was recovered in localities surrounding the colony. Examination made in 1912 showed them to be present in 10 widely separated points throughout the town. In 1913 and 1914 the beetles were common in all sections.

*Belmont.*—During 1911 larval molt skins were found in a number of localities, although no liberations were made here. In 1912, 1913, and 1914 beetles were present in all the infested localities.

*Berlin.*—No colonies were liberated here, but in 1913 beetles were found in two localities. Reports in 1914 show this species to be quite abundant.

*Beverly.*—During 1909, 200 beetle larvæ were liberated off Essex Street. In 1910 beetles were recovered in points surrounding the colony. This species was found in many localities in 1911, and in 1912, 1913, and 1914 it had become well established.

*Billerica.*—In 1909, 100 beetles were liberated. Examinations in 1912 showed them to be present in most of the woodland areas. This species was very common in 1913 and 1914.

*Bolton.*—Although no colonies were liberated here, the beetles were found in three localities in 1913. Reports show this species to be abundant in 1914.

*Boston.*—During 1910, 200 beetle larvæ were liberated in the Hyde Park district. In 1911 they were recovered in the Jamaica Plain and West Roxbury sections. Inspections in 1912 showed them to be common in the Hyde Park, Jamaica Plain, and Dorchester sections; also in Franklin Park. They were reported very common and doing efficient work in woodlands where gipsy moths were present in 1913 and 1914.

*Boxboro.*—No colonies were liberated here. Larval molt skins were found in one locality in 1912. During 1913 this species was found in other parts of the town, and in 1914 it had become quite common.

*Boxford.*—In 1910, 200 beetle larvæ were liberated. During 1912 larval molt skins were found in 10 widely separated localities. Additional data secured in 1913 and 1914 showed them to be well established throughout the town.

*Boylston.*—Although no colonies were planted here, beetles were recovered in one locality in 1913. In 1914 this species was reported from many sections of the town.

*Bradford.*—In 1910, 200 beetle larvæ were liberated. During 1912 larval molt skins were found in one locality. Reports in 1913 and 1914 show them to be rather common throughout the town.

*Braintree.*—Two hundred beetle larvæ were liberated here in 1909. Examinations during 1910 showed them to be present at and near the colony. In 1912 beetles were found in three separated localities. They were reported quite common in 1913 and 1914.

*Brockton.*—No colonies were liberated here, but in 1913 beetles were found in the northern part of the city. Further notes in 1914 showed that the beetles had increased considerably.

*Brookline.*—During 1908, 145 beetles and 100 beetle larvæ were liberated. In 1909, 200 beetle larvæ were added to another infested woodland. Examinations in the summer of 1909 showed that the beetles had migrated somewhat. During 1910 they were reported as reproducing and spreading favorably. In 1911 they had spread into 20 different localities and since that time they have steadily increased and have become well established.

*Burlington.*—Forty beetles were liberated here in 1906. In 1907 and 1908 a few larval molt skins were found. During 1909 beetles were found three-fourths of a mile from the colony, and in 1910 they were noted a considerable distance from the center of the original colony. In 1911 and 1912 this species was reported common in all sections of the town. Later reports show them to have increased and become well established.

*Canton.*—During 1911, 100 beetles were liberated. In 1912 larval molt skins were found in the center of the colony and in five isolated localities of the town. Reports of 1913 and 1914 show this species to be present in large numbers and steadily increasing.

*Carlisle.*—In 1910, 100 beetles were liberated. A thorough inspection was made in 1912 and they were recovered in a number of different localities. Since that time they have steadily increased and become effective.

*Carver.*—During 1913, 85 beetles were liberated. In 1914 larval molt skins were found common in all parts of the town where gipsy moths were present.

*Chelmsford.*—One hundred beetles were liberated here in 1910 and during 1912 they were recovered in several localities. Reports made in 1913 and 1914 found them present in large numbers.

*Clinton.*—No beetles were liberated here, but examinations made in 1914 show them to be rather common in all parts of the town.

*Cohasset.*—In 1909, 400 beetle larvæ were released in this town. During 1912 they were recovered in several localities. Additional data secured in 1913 and 1914 show this species to be well established.

*Concord.*—Fifty beetles and 100 beetle larvæ were liberated here in 1908, and 400 larvæ in 1909. Examinations made in 1910 indicated that they had spread a considerable distance from where the colonies were liberated. In 1911 and 1912 this species was recovered in several sections and reports made in 1913 and 1914 show them to be abundant in all localities.

*Danvers.*—During 1909, 300 beetle larvæ were liberated, and in 1910 they were recovered a short distance from the colony. Examinations made in 1911 resulted in finding molt skins in numerous localities. Further evidence secured in 1913 and 1914 showed this species to be well established.

*Dedham.*—In 1910, 200 beetle larvæ and in 1911, 100 beetles were liberated. Beetles were present in most of the woodlands in 1912. In 1913 and 1914 they were found to have increased considerably and had become well established.

*Dover.*—Two hundred beetle larvæ were liberated here in 1910. In 1912 larval molt skins were found in five widely separated localities. Data received

in 1913 gave evidence that they were well established, and in 1914 they were found to be very abundant.

*Dracut.*—In 1910, 100 beetles were liberated. During 1912 they were recovered in various localities. In 1913 and 1914 the species was well established and very abundant in some localities.

*Dunstable.*—No colonies were liberated in this town, but in 1912 beetles were found in three widely separated sections. Reports of 1913 and 1914 show this species to be rather abundant in various localities.

*Duxbury.*—Beetles were found in the northern part of this town in 1913, although none had been liberated. In 1914 examinations showed them to be present in all sections.

*Easton.*—In 1913, 100 beetles were liberated and reports in 1914 showed the beetles to have spread to other localities.

*East Bridgewater.*—No beetles were liberated here, but in 1914 they were found in localities where gipsy moths were present in sufficient numbers.

*Essex.*—In 1909, 549 beetle larvæ were liberated in three separated localities. Beetles were recovered at and near these colonies in 1910. During 1912 examinations showed them to be present in large numbers in all sections, and in 1913 and 1914 they were reported to be abundant in all gipsy-moth infestations.

*Fall River.*—No liberations were made here, but in 1914 Mr. Norman S. Easton, President of the Society of Natural History, reported finding an adult in the center of the city.

*Fitchburg.*—One hundred beetles were liberated in 1913 in the western part of the city. During 1914, 87 beetles were liberated on Ashburnham Hill Road and 87 near Burbank Hospital. Later reports show them to be present in nearly all of the wooded sections of the city.

*Foxboro.*—In 1913, 100 beetles were liberated in this town, and during 1914 they were recovered in three different localities.

*Framingham.*—Two hundred beetle larvæ were liberated in 1910 in the northeastern part of the town. During 1912 they were recovered in several locations in the eastern part and in 1913 the species was quite common in the western section. Further data secured in 1914 showed them to be quite abundant in all localities.

*Franklin.*—No beetles were liberated, but in 1914 larval molt skins were found in some sections of the town.

*Georgetown.*—In 1909, 200 beetle larvæ were liberated in the southern part of the town. They were recovered in and near the colony in 1910. During 1912 examinations showed them to be present in a number of localities, and they were reported to be abundant in 1913 and 1914.

*Gloucester.*—In 1908, 275 beetle larvæ were liberated in three localities of the town. Examinations in 1910 showed them to be present in localities some distance from the original colonies, while in 1911 they were recovered in several sections. They were reported abundant in a number of localities in 1913 and 1914.

*Grafton.*—90 beetles were liberated in the northern part of the town in 1914. Later in the season they were recovered in the northern and eastern sections.

*Groton.*—No colonies were liberated here, but examinations made in 1913 and additional data secured in 1914 indicated that the beetles were well distributed in all sections of the town.

*Groveland.*—In 1910, 200 beetle larvæ were liberated in the center of the town, and in 1913 they were recovered in several well-separated localities. Later reports show this species to be abundant in all sections.

*Halifax.*—Although no colonies were released in this town, beetles were found in nearly every locality examined in 1914.

*Hamilton.*—During 1909, 104 beetles and 100 beetle larvæ were colonized in this town. In 1912 they were found in several localities visited. Reports in 1913 and 1914 proved that this species was well distributed and quite abundant in some districts.

*Hanover.*—No beetles were liberated here, but a careful survey of the woodlands made in 1913 resulted in finding them in no less than nine well-distributed localities. Later reports indicate their increase and further spread.

*Hanson.*—While no colonies were liberated here, examinations in 1913 and reports made in 1914 showed them to be common in a number of localities where gipsy moths were in sufficient numbers.

*Harvard.*—No beetles were liberated in this town, but examinations made in woodlands infested by gipsy moths in 1913 gave proof that this species was present in nearly all localities. In 1914 they were reported quite common throughout.

*Haverhill.*—In 1910, 200 beetle larvæ were liberated in the southeastern part of the city. During 1912 they were recovered in several localities in the wooded sections. Later reports prove that this species is quite common in the areas infested by gipsy moths.

*Hingham.*—Eighty-three beetles were liberated here in 1912. Later in the year they were recovered in five different localities. In 1913 and 1914 they had become well established.

*Holbrook.*—No liberations were made in this town, but recoveries have been made in all the surrounding towns near the town line.

*Holden.*—In 1913, 190 beetle larvæ were liberated, and in 1914, 90 beetles were colonized off Princeton Road.

*Holliston.*—During 1913, 100 beetles were liberated in the central part of the town. They were recovered in one locality outside of the colony later in the year. As a result of examinations in 1914 it was found that this species had little chance of increase, as the gipsy-moth infestations were light.

*Hopkinton.*—One hundred beetles were liberated here in 1910. During 1913 they were recovered in one locality. No larval molt skins were found in 1914, the gipsy-moth infestation being very light.

*Hudson.*—In 1910, 100 beetles were liberated on Priest's Hill. Examinations in 1912 showed them to be present in a number of locations. In 1913 and 1914 this species had become quite abundant throughout the town.

*Ipswich.*—During 1909, 200 beetle larvæ were liberated in the northern part of the town. Larval molt skins were recovered in large numbers in some localities during 1912. Reports received in 1913 and 1914 show that the species had increased and was well established.

*Kingston.*—In 1912, 93 beetles were liberated here. They were recovered in four near-by localities in 1913, and scouting in 1914 showed them to be present in all parts of the town.

*Lakeville.*—No colonies were liberated here, but larval molt skins were found in the center of the town in 1914.

*Lancaster.*—No liberations were made here, but in 1912 beetles were noticed in a few localities. Reports in 1914 show them to be quite common in a number of sections.

*Lawrence.*—Two hundred beetle larvæ were liberated in South Lawrence in 1910. In 1911 they were not recovered, except in adjoining towns near the city line. During 1913 and 1914 they were reported in large numbers in all the wooded sections.

*Leicester.*—Although no beetles have been liberated here, they were reported as being present in the southern part of the town in 1914.

*Leominster.*—In 1913, 200 beetle larvæ were liberated in the southeastern part of the town. From examinations made the same year they were found present in a few localities quite remote from the original colony, and in 1914 well distributed.

*Lexington.*—During 1908, 100 beetle larvæ were liberated off State Road, and in 1909, 200 larvæ were colonized in the eastern part of the town. A careful examination was made in all infested woodlands in 1912, and beetles were recovered in 40 different localities. Later reports prove that they are abundant and doing efficient work.

*Lincoln.*—In 1908, 100 beetle larvæ were liberated in the northwestern section. During 1910 they were recovered in localities somewhat remote from the colony. Examinations in 1911 and 1912 showed them to be present in all the localities infested by gipsy moths, and since that time their effective work has been very noticeable.

*Littleton.*—In 1910, 200 beetle larvæ were liberated a short distance from the railroad station. During 1912 examinations showed them to be quite common in some localities. Later they were reported abundant in most sections of the town.

*Lowell.*—During 1910, 200 beetle larvæ were liberated near the Lowell General Hospital. In 1912 they were recovered in five different localities. In 1913 and 1914 the species had increased and was doing efficient work in the woodland areas.

*Lunenburg.*—No colonies were liberated in this town, but in 1913 beetles were recovered in a few localities in the eastern part. During 1914 they had spread to all sections, and in one point near the center they had increased to such proportions that the adults and small larvæ destroyed about 49 per cent of the gipsy-moth caterpillars. As a result of counts made after the gipsy moths had reached the pupal stage it was found that about 78 per cent of the pupæ were destroyed by the beetle larvæ alone.

*Lynn.*—No colonies were liberated in this city, but colonies were planted in Lynnfield and Saugus near the Lynn Woods Reservation. In 1910 beetles were recovered in a number of localities in the reservation. Examinations in 1911 showed them to be well established in nearly all parts of this woodland. Since that year they have continued to increase and have assisted materially in lessening the damage done to these woodlands by the gipsy moths.

*Lynnfield.*—In 1906, 100 *C. sycophanta* and 20 *C. inquisitor* adults were liberated near Broadway. Later this same year 218 of the former species were colonized two miles distant. *C. sycophanta* was recovered in 1908 and 1909. From examinations in 1910 these beetles were found spread throughout the southern part of the town, and since that time they have increased in large numbers and are doing satisfactory work.

*Malden.*—During 1906, 40 beetles were liberated in the Maplewood section. They were recovered in a few localities in 1908 and 1909. This species from 1910 to 1914 was found to have spread to all sections and was doing very efficient work in destroying the gipsy moths.

*Manchester.*—In 1909, 73 beetles and 850 beetle larvæ were liberated in five localities of this town. Scouting in 1911 showed them to be present in and at a considerable distance from the colonies. In 1912 this species was found to be common in many of the woodland areas. During 1913 and 1914 they had become well established throughout.

*Mansfield.*—No beetles were liberated, but in 1914 larval molt skins were found in a few localities.

*Marblehead.*—In 1908, 200 beetle larvæ were liberated one-half mile east of Forest River station. They were recovered in small numbers in 1910. Examinations made in 1911 showed them to be present in and at some distance from the original colony. Later reports indicate that this species has increased to great numbers in some localities.

*Marlboro.*—No beetles were liberated in this town, but in 1912 larval molt skins were found in woodlands in the northeastern part. During 1913 they were found in the southern and western sections. Later reports show that this species is rather common in the wooded sections of the city.

*Marshfield.*—In 1910, 200 beetle larvæ were liberated near Marshfield Center. During 1913 several examinations were made, and larval molt skins were found in a number of widely separated localities. Later reports show them to be well established.

*Mashpee.*—Eighty-five beetles were liberated in 1913 in woodland north of Wakeby Pond and 316 beetle larvæ in woodland south of Johns Pond. As a result of scouting in 1914, it was found that this species had dispersed into most of the infested sections of the town.

*Maynard.*—In 1910, 200 beetle larvæ were liberated in badly infested woodland. Observations were made in 1912, and the species was recovered in and around the colony. In 1913 and 1914 the species had become well established throughout the town.

*Medfield.*—During 1910, 100 beetles were liberated in Rocky Woods. In 1912 larval molt skins were found in a few localities around the colony. As a result of further scouting in 1913 and 1914 it was found that they were rapidly spreading and increasing.

*Medford.*—No beetles were liberated here, but in 1910 indications of their presence were noted in the northern part of the city. Later reports show them to be common in all the woodland areas.

*Medway.*—In 1913, 100 beetles were liberated in Black Swamp. They were recovered in a few woodland areas in 1914.

*Melrose.*—During 1909, 200 beetle larvæ were liberated in woodland near the Saugus-Wakefield line. Beetles were found in small numbers throughout the entire area in 1910. This species at the present time is common and doing efficient work in all the woodland areas.

*Merrimac.*—Two hundred beetle larvæ were liberated north of Main Street, in Nichols Woods. Molt skins were secured in a few localities in 1912. In 1913 and 1914 they had become quite common in some sections.

*Methuen.*—During 1910, 200 beetle larvæ were liberated in the eastern part of the town near the Haverhill line. Their presence was noted in 20 or more localities in 1912, and a constant increase and spread has been reported since that time.

*Middleboro.*—In 1913, 85 beetles were liberated in woodland infested by the gipsy moth off Wareham Street This species was recovered in all parts of the town in 1914.

*Middleton.*—One hundred beetles were liberated in woodland off East Street in 1910, and in 1911 they were recovered in a number of localities. Further examinations in 1912 showed that the beetles were still increasing and had become well established in 1913 and 1914.

*Milford.*—No liberations were made in this town, but it was reported that beetles were seen in the northern part of the town, near the Hopkinton line, in 1914.

*Millbury.*—No beetles were liberated here, but scouting in 1914 showed them to be present in small numbers in some parts of the town.

*Millis.*—In 1913, 100 beetles were liberated in the northern part of the town, and in 1914, 95 adults were liberated in the eastern part. As a result of examinations in 1914, it was found that this species had spread rapidly and could be found in all sections of the town.

*Milton-Quincy.*—During 1909, 200 beetle larvæ were liberated near Shawmut Spring, in Cunningham Park. In 1912 beetles were recovered in 14 different localities of the former town. This species became very abundant in 1913 and 1914 in badly infested sections.

*Natick-Weston.*—Two hundred larvæ were liberated near the Natick-Weston line in 1910. Larval molt skins were found in a few localities in Natick in 1911. Evidences of the beetles were noticed in 1912 and in 1913, and by 1914 this species had become very abundant in some localities.

*Needham.*—In 1911, 100 beetles were liberated in woodland off Central Avenue. During 1912 examinations showed them to be present in five or more localities. Data secured in 1913 and 1914 indicated that the species was spreading and increasing rapidly.

*Newbury.*—During 1910, 88 beetles were liberated in badly infested woodland near Byfield Station. In 1912 they were recovered in several sections throughout the town. Later reports show them to be quite common in areas infested by gipsy moths.

*Newburyport.*—During 1910, 200 beetle larvæ were liberated in woodland near West Newbury line. Larval molt skins were found in several locations in 1912. In 1913 and 1914 the beetles were very abundant in all the woodland areas.

*Newton.*—In 1908, 100 beetle larvæ were liberated, and in 1909 400 more were colonized in two other localities. During 1910 they were recovered in and around the colonies. As a result of examinations in 1911 they were found in most of the wooded sections of the city, and later reports indicate that they are quite common in all the districts infested by gipsy moths.

*Norfolk.*—Ninety beetles were liberated in the western part of this town near Populatic Pond in 1914. Later they were recovered in localities around the colony.

*North Andover.*—In 1910, 100 beetles were liberated in badly infested woodland off Osgood Street. Scouting in 1912 showed them to be present in a number of localities. In 1913 and 1914 they were reported numerous, and in some cases the larvæ had consumed nearly all the gipsy-moth pupæ on the trees 8 feet from the ground.

*Northboro.*—During 1913, 190 beetle larvæ were liberated near the Metropolitan Aqueduct. As a result of examinations in 1914 they were found to be present in a number of localities.

*North Reading.*—In 1910, 200 beetle larvæ were liberated in woodland one-half mile from the State road. They were recovered in a few separated woodlands in 1911. During 1912 this species was quite common in a number of localities, and later reports indicate that they are abundant in all the woodland areas.

*Norton.*—During 1914, 95 beetles were liberated in the eastern part, and 90 more in the northern part of the town.

*Norwell.*—*C. sycophanta* beetles were found in the northwestern part of the town in 1912. In 1913, 308 beetle larvæ were liberated in woodland off Main Street, in a rather heavy gipsy-moth infestation. Examinations made later in the year showed them to be present in many localities and in 1914 rapidly increasing.

*Norwood.*—No beetles were liberated in this town, but they were found in one locality in 1912. Scouting in 1913 showed them to be present in all sections of the town, and in 1914 they were found to be abundant in several wooded areas.

*Peabody.*—Fifty beetles were liberated in a badly infested woodland in 1907. In 1909, 100 beetles were liberated in woodland near Middleton Paper Mills, 100 beetle larvæ off Birch Street, and 200 larvæ in woodland off West Street, near West Peabody Station. Several woodlands were examined in 1911 and molt skins were found in many locations. During 1912 the adults of this species were seen in large numbers by the inhabitants of West Peabody. Evidence of the beetles' good work was seen in all localities in 1913 and 1914.

*Pembroke.*—No liberations were made here, but examinations in 1913 showed them to be present in all localities, being well established in the southern part of the town. In 1914 they were more common in most sections where gipsy moths were present in sufficient numbers.

*Pepperell.*—No beetles were liberated here, but several woodlands were examined in 1913, and larval molt skins were found in a few localities. In 1914 this species was common and doing efficient work in all the woodland areas.

*Phillipston.*—No liberations were made here, but in 1914 three beetles were seen in the northern section of the town about 1½ miles south of South Royalston Station. These undoubtedly dispersed from the colony liberated at East Templeton in 1913.

*Plymouth.*—In 1911, 21 beetles and 135 beetle larvæ were liberated on the estate of Mr. B. M. Watson. They were recovered in and around the colony in 1913. Examinations in 1914 showed them to be present in moderate numbers in the northern and central parts of the town.

*Plympton.*—No liberations were made here, but in 1914 larval molt skins were found in all sections of the town where gipsy moths were present in sufficient numbers.

*Princeton.*—In 1913, 195 beetle larvæ were liberated in woodland off East Princeton road. During 1914, 180 beetles were liberated at John Chandler's farm, on Princeton-West Sterling road. Later reports show this species to be increasing and spreading satisfactorily.

*Provincetown.*—In 1914, 100 beetles were liberated in badly infested woodland in Province Lands.

*Quincy.*—During 1909, 200 beetle larvæ were liberated in woodland off South Street. In 1910 the adults and larvæ were found in abundance in and around the colony; 134 beetle larvæ were added to this colony in 1911. This species was recovered in 1912 in several localities far remote from the site of the original colony. In 1913 and 1914 they had continued to increase and spread rapidly.

*Randolph.*—No liberations were made here, but larval molt skins were found in a number of sections throughout the town in 1913. A slight increase and spread was noted in 1914.

*Raynham.*—In 1913, 100 beetles were liberated in woodland at the corner of Forest and Locust Streets. During 1914, 100 beetles were colonized in the central part of the town. This species is spreading rapidly and doing good work in limited localities.

*Reading.*—No colonies have been liberated here, but larval molt skins were found in the southeastern and central parts in 1910. Scouting in 1911 showed them to be present over the whole area, and in some cases quite numerous. In 1912 larvæ were found commonly throughout. Later reports indicate that they are very numerous and doing efficient work in the infested areas.

*Revere.*—During 1908, 300 beetle larvæ were colonized in infested woodland on Oak Island. Some visits were made in and around the colony in 1911 and they were seen in large numbers. Later reports indicate that this species is well established.

*Rockland.*—In 1913, as a result of scouting several woodlands in various parts of the town, it was found that larval molt skins were present in several widely separated districts. During 1914 the beetles had increased rapidly and were doing very efficient work in gipsy-moth infested areas.

*Rockport.*—In 1910, 200 beetle larvæ were liberated in woodland in the rear of Manning Park. Larval molt skins were found present in several widely separated districts in 1912. During 1913 and 1914 they had become quite common in a number of localities.

*Rowley.*—Two hundred beetle larvæ were liberated in infested woodland off the Newburyport Turnpike in 1910. During 1912 several examinations were made and it was found that the beetles were present in several localities. Later reports indicate that the species is present in all sections where gipsy moths are found in sufficient numbers.

*Rutland.*—No liberations were made here, but a few beetles were reported from the eastern part of the town in 1914.

*Salem.*—No colonies have been liberated in this city, but in 1910 an examination showed them to be present over a large area in the southern part of the city. Scouting in 1911 indicated that they had increased and spread over a much larger area. This species at the present time is common in all the infested districts.

*Salisbury.*—In 1910, 200 beetle larvæ were liberated in infested woodland, and during 1912 they were recovered in several of the wooded areas. In 1913 and 1914 the species was common in all sections of the town and quite a number were seen around the cottages at Salisbury Beach.

*Sandwich.*—No beetles were liberated in this town, but as a result of scouting in 1914 it was found that they were present in small numbers in the southeastern and southern parts.

*Saugus.*—During 1906, 49 beetles were liberated in woodland in the northern section. In 1907, 33 beetles were liberated in infested woodland north of the former gipsy-moth laboratory at North Saugus. During 1911, 34 beetles were seen by Mr. C. W. Collins in a small area in the above district. Two hundred and fifty beetles to be used for transplanting were collected in a small woodland in the northern part of the town in 1913, showing that the beetles were quite numerous. This species has spread rapidly and was well established in all parts of the town in 1914.

*Scituate.*—In 1911, 835 beetle larvæ were liberated in a woodlot at the corner of Elm and Main Streets. Examinations in 1912 showed them to have multiplied and spread quite a distance from the center of the colony. Later reports indicate that they had dispersed to all parts of the town and were well established.

*Sharon.*—One hundred beetles were liberated in woodland near Sharon Sanitarium in 1913. During 1914 several localities were scouted and larval molt skins were found in a number of infested districts.

*Sherborn.*—During 1910, 200 beetle larvæ were liberated in infested woodland off Main Street. Examinations were made in scattered woodlands throughout the town in 1913 and larval molt skins were recovered in several localities. In 1914 they continued to increase and spread and had become well established.

*Shirley.*—No liberations were made here, but examinations made in 1913 and later reports in 1914 showed the beetles to be present in several separated districts.

*Shrewsbury.*—In 1913, 250 beetle larvæ were liberated in an apple orchard off Oak Street and 90 adults in the northern part of the town in 1914. As a result of scouting in 1914, it was found that this species was present in all locations where gipsy moths were present in sufficient numbers.

*Southboro.*—No colonies were liberated here, but in 1913 beetles were found in one locality in the eastern section. During 1914 they had increased and spread to other localities.

*Sterling.*—During 1913, 200 beetle larvæ were liberated in woodland near the post office. In 1914 larval molt skins were found in all parts of the town, but in small numbers, showing that the beetles had spread and will in time become abundant.

*Stoneham.*—In 1908, 75 beetles were liberated in woodland off Franklin Street. During 1909 a few of these were recovered. Larval molt skins were found in the eastern and southern parts of the town in 1910. In 1911 and 1912 this species had increased and spread throughout, being very abundant in some localities. Since that time the beetles have become abundant in all gipsy-moth infested areas.

*Stoughton.*—During 1911, 100 beetles were liberated in infested woodland off Turnpike Street. In 1914 larval molt skins were found in one locality. Infestations in most sections of the town were very light, hence the slow increase of beetles.

*Stow.*—Eighty-six beetles were liberated in this town in 1910. In 1912 larval molt skins were found in 11 or more separated localities. This species had become well established in 1913 and 1914 and could be found very abundant in some sections of the town.

*Sudbury.*—In 1910, 200 beetle larvæ were liberated in woodland in East Sudbury. Larval molt skins were recovered in a few localities in 1911, and in 1912 had increased and spread to most sections of the town. Reports received in 1913 and 1914 show this species to be present in all sections and in some cases very abundant.

*Swampscott.*—During 1908, 175 beetle larvæ were liberated in woodland off Danvers Street and 200 larvæ were colonized north of the Ocean House. In 1910 beetles were recovered in and at some distance from the colonies. This species had increased and spread to a number of localities in 1911 and 1912. Later reports indicate a similar increase and spread.

*Taunton.*—In 1913, 100 beetles were liberated off Bay Street, and in 1914, 95 adults were colonized in woodland in the southeastern part of the city. Recoveries were made near the colonies in 1914.

*Templeton.*—During 1913, 200 beetle larvæ were liberated off Petersham Road. Beetles were recovered in and near the colony in 1914.

*Tewksbury.*—In 1908, 100 beetle larvæ were liberated in woodland infested by gipsy moths. During 1910, 100 beetles were liberated off Shawsheen Avenue and 200 larvæ near Prospect Hill. In 1912 larval molt skins were recovered in 12 or more widely separated localities. Since that time the beetles have spread and become quite abundant in a number of the infested woodlands.

*Topsfield.*—In 1910, 180 beetle larvæ were liberated off High Street. During 1911 some scouting was done and larval molt skins were found in several woodlands. During 1912 molt skins were found in eight or more different localities. Further reports in 1913 and 1914 showed that the beetles had increased and become well established throughout.

*Townsend.*—No liberations were made in this town, but a few molted skins were found in two well-separated localities in 1913. Reports from here in 1914 show that the beetles were very plentiful, and could be found in most of the infested areas.

*Tyngsboro.*—No beetles were liberated here, but in 1912 several woodlands were examined, and larval molt skins found in a number of well-separated localities. Further data secured in 1913 and 1914 indicated that the beetles

had increased extensively, and results of their work were becoming very evident.

*Wakefield.*—No beetles were colonized here, but in 1909 they were found in the eastern part of the town, and in 1910 could be found in various localities. During 1911 and 1912 they had increased and spread throughout, and are now assisting greatly in lessening the damage done by the gipsy moth.

*Walpole.*—In 1913, 100 beetles were liberated in a wood lot off North Street. As a result of scouting in 1914, it was found that this species was present in several localities throughout the town.

*Waltham.*—During 1908, 100 beetle larvæ were liberated off Lake Street. In 1910 they were recovered in and at some distance from the original colony. During 1911 a general scout was made, and molt skins were found in most of the woodlands visited. Since that time the beetles have become well established, and are very abundant in some localities.

*Wareham.*—No liberations were made here, but as a result of scouting during 1914 the species was found to be present in a few localities in the northwestern part of the town.

*Watertown.*—No beetles were liberated, but evidences of their presence were noted in several localities in 1911. Since that time they have increased and spread throughout all the woodland areas.

*Wayland.*—During 1909, 200 beetle larvæ were liberated in infested woodland off Poor Farm Road. In 1910 they were recovered in and around the original colony. During 1911 and 1912 the beetles had spread and become well established in the infested areas. Further reports indicate that they are still increasing and have become quite abundant in several localities.

*Wellesley.*—In 1908, 223 beetles were liberated in infested woodland near Wellesley Farms Station. In 1909 they were recovered in and at some distance from the original colony, while in 1910 they were scattered over a larger area. During 1911 larval molt skins were recovered in practically all parts of the town. In 1912 the beetles had increased to such an extent that over 2,000 larvæ were collected under burlaps for further colonization without depleting the stock. In 1913, 3,500 beetle larvæ were collected in a limited area of the town, and during 1914 beetles were collected in large numbers for recolonization.

*Wenham.*—In 1908, 12 beetles and 75 beetle larvæ were liberated off Cherry Street. During 1909, 73 beetles and 100 beetle larvæ were colonized off Grapevine Road. In 1910 beetles were found in and at quite a distance from the original colonies. During 1911 and 1912 the species had increased and spread over large areas. Since that time they have become well established, and in some localities very abundant.

*Westboro.*—No liberations were made here, but in 1914 beetles were found in a number of localities throughout the town.

*West Boylston.*—In 1914, 90 beetles were liberated in infested woodland off Prescott Street. During the late summer larvæ were seen in large numbers in and around the colony.

*West Bridgewater.*—No beetles were liberated here, but in 1914 some scouting was done, and larval molt skins were found in the southwestern part of the town.

*Westford.*—During 1910, 100 beetle larvæ were liberated in the northern part of the town. Examinations in 1912 showed that the beetles had spread over a rather large area in the eastern section. In 1913 and 1914 further reports indicated that they had increased and were becoming quite numerous.

*Westminster.*—In 1913, 100 beetles and 200 beetle larvæ were liberated near Bean Porridge Hill, and in 1914, 87 adults were colonized off Westminster Hill

Road. Scouting was done in 1914, and this species was recovered in and at some distance from the original colonies.

*Weston.*—During 1909, 200 beetle larvæ were liberated in woodland near railroad station. Several larval molt skins were found in the area surrounding the colony in 1910. In 1911 the beetles had spread to all sections, and in some cases quite numerously. Later reports indicate that they have become well established in all parts of the town.

*West Newbury.*—Two hundred beetle larvæ were liberated on Pipestave Hill in 1910. Scouting in 1912 resulted in finding molt skins in several well separated localities. Later data secured show that they are very common in all the infested woodlands.

*Westwood.*—In 1910, 200 beetle larvæ were liberated in badly infested woodland, and in 1911, 100 beetles were colonized in woodland off Canton Street. Several woodlands were scouted in 1912, and molt skins were found over the entire area. Since that time this species has become common throughout.

*Weymouth.*—During 1909, 200 beetle larvæ were colonized in woodland off Commercial Street. In 1910 molt skins were found abundant in and around the colony. During 1911 and 1912 the beetles had become well distributed throughout, and in 1913 and 1914 they had increased extensively.

*Wilmington.*—Two hundred beetle larvæ were liberated near the central part of the town in 1910. In 1911 it was found that the beetles had spread throughout. During 1913 and 1914 they had become so numerous that it was possible to collect many adults and larvæ for further colonization work.

*Winchester.*—In 1906, 41 beetles were liberated off High Street. During 1910 larval molt skins were found quite a distance from the original colony. Examinations in 1911 showed that the beetles had dispersed over a greater part of the town and since that time have continued to increase.

*Woburn.*—During 1907, 97 beetles were liberated in woodland near North Woburn. In 1909 beetles were found in the colony, and larval molt skins were found a mile distant. Data secured in 1910 and 1911 showed that the beetles had increased considerably and had dispersed to all sections of the city. Since that time this species has continued to increase, and is common in all the woodland areas infested by gipsy moths.

*Worcester.*—In 1913, 150 beetle larvæ were liberated in an apple orchard at the corner of Pleasant and Moreland Streets. Larval molt skins were found quite abundantly in the western part of the city in 1914, and a colony of 90 beetles was liberated the same year near Lake Quinsigamond.

*Wrentham.*—In 1914, 90 beetles were liberated in the northern part of the town, off Bennett Street.

### New Hampshire.

*Allenstown.*—No colonies were liberated in this town, but in 1913 beetles were found in the southern part. In 1914 they had spread to all sections.

*Alton.*—In 1914, 90 beetles were liberated in this town near Spring Haven Station, 90 north of Alton Station, and 90 near Merry Meeting Pond, the last being colonized by Prof. W. C. O'Kane.

*Amherst.*—Although no colonies were liberated in this town, evidence secured in 1913 showed that the beetles were present in 10 or more widely separated localities, and in 1914 had become quite common.

*Andover.*—In 1914 beetles were found in the eastern part of the town, although no liberations were made.

*Atkinson.*—Larval molt skins were found in several different localities in this town during 1912. Later reports show them to have become well established.

*Auburn.*—In 1913 beetles were found present in several localities and during 1914 they had become quite common.

*Barnstead.*—During 1914, 42 beetle larvæ were liberated in the central part of this town by Prof. W. C. O'Kane. Later they were recovered in the eastern part, where they had spread from other towns.

*Barrington.*—Although no colonies were liberated here, larval molt skins were found in several sections during 1914.

*Bedford.*—Scouting during 1913 showed that the beetles were present in several areas and in 1914 they had become quite numerous.

*Boscawen.*—No liberations were made here, but beetles were found in two widely separated localities in 1914.

*Bow.*—In 1913, 85 beetles were liberated in woodland near Bow Mills. During 1914 they were found in a number of well-separated sections.

*Brookfield.*—During 1914, 100 beetles were liberated 2 miles west of Sanbornville Station, 77 on road to Copplecrow Mountain (4 miles from Sanbornville Station), and 56 beetle larvæ one-half mile north of Brookfield Center. The two latter colonies were liberated by Prof. W. C. O'Kane.

*Brookline.*—No colonies were liberated in this town, but larval molt skins were found in the northern part in 1913, and during 1914 they had increased and spread to a number of localities.

*Candia.*—During 1913 larval molt skins were found in several scattered woodlands, showing that the beetles had dispersed here from other near-by sections. Further data secured in 1914 show that the beetles were common throughout.

*Canterbury.*—One hundred beetles were liberated in this town in 1913. They were recovered in six widely separated localities in 1914.

*Chester.*—Beetles were found to be present in a number of localities in this town during 1913 and 1914.

*Chichester.*—In 1914, 100 beetles were liberated in the southern part of the town by Prof. W. C. O'Kane. Larval molt skins were also found in this section in 1914.

*Concord.*—In 1913, 85 beetles were liberated in woodland near West Concord post office. During 1914 larval molt skins were found in all the infested woodlands.

*Danville.*—Examinations of some woodlands in 1913 showed that the beetles had dispersed here, and in 1914 were well distributed over the entire area.

*Deerfield.*—No liberations were made here, but in 1914 the beetles were common throughout, and in some localities very abundant.

*Deering.*—During 1914 beetles were found quite abundant in two well-separated localities.

*Derry.*—During 1912 and 1913 larval molt skins were found in several widely separated localities. Since that time they have become well established throughout.

*Dover.*—No colonies were liberated here, but in 1913 and 1914 larval molt skins were found in well-separated localities.

*Dunbarton.*—As a result of scouting in 1914, beetles were found in six well-separated localities.

*Durham.*—No beetles were liberated here, but in 1913 and 1914 they had become well established in all parts of the town.

*Effingham.*—During 1914, 100 beetles and 68 beetle larvæ were liberated in this town by Prof. W. C. O'Kane.

*Epping.*—During 1913 examinations of woodland showed that the beetles had entered this town, and were present over a limited area. They were reported quite common throughout in 1914.

*Epsom.*—In 1914, 100 beetles were liberated three-fourths of a mile from Short Falls Station by Prof. W. C. O'Kane.

*Exeter.*—No liberations were made here, but in 1912 beetles were found in the eastern and southern sections. In 1913 and 1914 they had spread to all parts of the town and were increasing extensively.

*Farmington.*—Examinations in 1914 showed the beetles to be present in eight widely separated localities.

*Fitzwilliam.*—In 1914, 300 beetles were colonized in three widely separated localities in this town.

*Francistown.*—In 1914, as a result of scouting, larval molt skins were found in the eastern, southern, and central parts of this town.

*Fremont.*—No beetles were liberated here, but in 1912 they were found in three different localities in the southern part of the town. In 1913 and 1914 they had become well established in all the infested woodlands.

*Goffstown.*—During 1913, 100 beetles were liberated in woodland near Sawyers Crossing. Larval molt skins were found in the northern, western, and south-central parts of the town in 1914, and were abundant in some sections.

*Gilmanton.*—In 1914, 90 beetles were liberated in the northwestern part of the town. Later the same year 61 beetle larvæ were colonized by Prof. W. C. O'Kane.

*Greenville.*—In 1914 beetles were reported from all sections of the town.

*Hampstead.*—During 1912 larval molt skins were found in a few localities. Further reports indicate that they are well established throughout the town.

*Hampton.*—Examinations of woodlands during 1912 showed that the beetles had dispersed into the town. In 1913 they were found quite commonly in several localities, and during 1914 they were well established in all the woodland areas.

*Hampton Falls.*—Beetles were found in small numbers in this town during 1912, and in 1913 and 1914 they were reported very abundant in some localities.

*Henniker.*—In 1914, 54 beetles were liberated in the northwestern part of this town. Later in the year they were recovered in the northeastern, eastern, and southern sections .

*Hollis.*—In 1912 beetles were found in four or more separated localities. Since that time they have increased and spread to all the infested woodlands.

*Hooksett.*—Eighty-five beetles were liberated here in 1913. Later in the year larval molt skins were found in a few scattered localities, indicating that the beetles had also spread here from neighboring towns. During 1914 they had become well established throughout.

*Hopkinton.*—During 1913, 85 beetles were liberated here. In 1914 they were found in the southeastern, eastern, and northwestern parts of the town.

*Hudson.*—A number of localities were scouted in this town in 1912 and 1913, and larval molt skins were found in many sections. In 1914 they had continued to increase and spread to all infested areas.

*Kensington.*—Evidences of the beetles' presence were found in this town during 1912. Since that time they have increased and spread to all the infested woodlands.

*Kingston.*—Beetles were found present here in several localities in 1912. During 1913 and 1914 they had increased and dispersed to all the gipsy-moth infested areas.

*Lee.*—In 1913 beetles were found in a few separated localities, and during 1914 they had continued to increase and spread to all sections of the town.

*Litchfield.*—Larval molt skins were found in three or more separated localities in this town during 1913, and in 1914 they had become quite common.

*Londonderry.*—No liberations were made here, but larval molt skins were found in 12 different localities in 1913. They were reported doing efficient work in the infested woodlands in 1914.

*Louden.*—In 1914 larval molt skins were found in small numbers in the northeastern part of the town.

*Lyndeboro.*—Beetles were found in the southeastern part of the town in 1913, and during 1914 they had increased and spread to a number of well-separated localities.

*Madbury.*—During 1913 beetles had made their appearance in a few localities, and in 1914 they were well distributed throughout the town.

*Manchester.*—In 1913, 100 beetles were liberated in woodland off Mammoth Road. Later examinations showed that they were present in several localities; this species evidently had spread from nearby towns, and in 1914 was reported common throughout.

*Mason.*—A few beetles were found in the eastern part of this town in 1913, and in 1914 they were reported from various localities.

*Merrimac.*—Larval molt skins were found in several widely separated localities in 1913. During 1914 they had become well established throughout.

*Middleton.*—Seventy-one beetle larvæ were liberated in woodland off Ridge Road by Prof. W. C. O'Kane in 1914.

*Milford.*—Evidence of the beetles' presence was found in a number of localities in this town during 1914.

*Milton.*—In 1913, 200 beetle larvæ were liberated off State road near railroad station. During 1914, as a result of scouting, they were found in all parts of the town.

*Mont Vernon.*—Larval molt skins were found in four well-separated localities in 1913. Since that time this species has continued to increase and is doing efficient work in the infested areas.

*Nashua.*—In 1912 and 1913 larval molt skins were found in a number of well-separated localities. Reports in 1914 show that they are quite common throughout.

*New Boston.*—During 1913, 85 beetles were liberated in woodland off Francistown Road, and 85 more near Old Muzzy Hill. In 1914 larval molt skins were found in all sections of the town, being quite abundant in some localities.

*New Durham.*—In 1914, 90 beetles were liberated in woodland southwest of Davis Station and 104 were colonized by Prof. W. C. O'Kane off road from New Durham to Farmington.

*Newfields.*—Evidence of the beetles presence in this town was found in several woodlands during 1913 and 1914.

*Newington.*—A few larval molt skins were found near the Portsmouth line in 1912, and during 1913 the beetles had spread over the greater part of the town. In 1914 they were well established in all the woodlands infested by gipsy moths.

*New Ipswich.*—In 1913, 100 beetles were liberated in a woodland off King Road. Examinations here in 1914 showed that the beetles were present in a few separated localities.

*Newmarket.*—Larval molt skins were found in a few localities near the center of the town in 1913. Since that time they have increased and spread to all sections.

*Newton.*—In 1913 and 1914 beetles were found in a number of separated localities. Later reports indicate that they are still present and increasing.

*North Hampton.*—Beetles were found present here in a few localities in 1912. Data secured since that time show that they have become well established, being abundant in some localities.

*Northwood.*—Beetles were found here in a few localities in 1914.

*Nottingham.*—Scouting in this town during 1913 showed the beetles to be present in the eastern and central sections, and in 1914 they were well distributed throughout.

*Ossipee.*—In 1914, 32 beetle larvæ were colonized in woodland near Leightons Corner by Prof W. C. O'Kane.

*Pelham.*—Larval molt skins were found in a number of localities in 1912. During 1913 and 1914 they had increased and spread to all sections of the town.

*Pembroke.*—During 1913 larval molt skins were found in a few localities in the southern part of the town and in 1914 they were present in most of the infested woodlands.

*Pittsfield.*—In 1914 larval molt skins were found in the southwestern corner of this town.

*Plaistow.*—Examinations made here during 1912 and 1913 showed that the beetles were well established, and in 1914 they were found very abundant in some localities.

*Portsmouth.*—Examinations during 1912 showed that the beetles were present in a few localities, and in 1913 and 1914 they were common throughout the woodland areas.

*Raymond.*—A careful scout made here in 1913 showed the beetles to be present in several localities. Since that time they have continued to increase and are doing efficient work in the gipsy-moth infested areas.

*Richmond.*—Beetles were found here in small numbers in 1914.

*Rindge.*—During 1913, 40 beetles and 102 beetle larvæ were liberated in the southern part of the town, and in 1914, 100 beetles were liberated in a woodland 1½ miles east of West Rindge station.

*Rochester.*—In 1913 larval molt skins were found in the southern part of the town and during 1914 they were recovered in nine well-separated localities.

*Rollingsford.*—As a result of examinations in 1914 beetles were found to be common in a number of well-separated woodlands.

*Rye.*—No liberations were made here, but larval molt skins were found in moderate numbers during 1912 and 1913. In 1914 they had become well established throughout.

*Salem.*—Beetles were found present in a number of localities in this town during 1912. Since that time they have continued to increase and spread to all the infested areas.

*Sandown.*—Larval molt skins were found here in a few localities in 1912. In 1913 and 1914 the beetles had dispersed to all the infested areas.

*Sandwich-Tamworth.*—In 1909, 100 beetle larvæ were liberated near Sandwich-Tamworth line, in woodland which was being defoliated by *Heterocampa guttivitta* Walk. and *Anisota rubicunda* Fab. Gipsy moths had not been found in this region, but it was desired to see whether the beetles would feed on these species and survive the winter. In 1910 and 1913 scouting was done, but no beetles were recovered.

*Seabrook.*—During 1912 examinations were made in several parts of the town and as a result larval molt skins were found in a few localities. Further data secured in 1913 and 1914 showed that the beetles had increased extensively.

*Somersworth.*—No liberations were made, but in 1914 larval molt skins were found in a number of well-separated localities.

*Southampton.*—Scouting in 1913 showed the beetles to be present in a few localities in the western part of the town. Since that time they have continued to increase and spread to the infested woodlands.

*Strafford.*—During 1913 and 1914 examinations were made in several woodlands, and larval molt skins were found in a few well-separated localities.

*Stratham.*—In 1912 and 1913 larval molt skins were recovered in a few separated wooded areas of the town, indicating that the beetles had spread from other near-by sections. During 1914 the beetle had become quite common throughout.

*Temple.*—During 1913, 100 beetles were liberated in infested woodland on Haywood Hill. Scouting in 1914 showed them to be present in a few well-separated localities.

*Wakefield.*—In 1914, 100 beetles were liberated in woodland on the southwestern shore of Great East Pond, and 100 more were colonized in this town by Prof. W. C. O'Kane.

*Weare.*—No liberations were made here, but larval molt skins were found in four well-separated localities in 1914.

*Webster.*—During 1913, 85 beetles were liberated in woodland near Holmes Hill. In 1914 they were recovered in and around the colony, also in the southeastern and southwestern parts of the town.

*Wilton.*—During 1913, 100 beetles were liberated in infested woodland on Abbott Hill. Examinations in 1914 showed that they were well distributed and quite abundant in some localities.

*Windham.*—Examinations made here in 1912 showed that the beetles were present in a few localities in the eastern and southern parts of the town. In 1913 and 1914 they had increased considerably, and were doing very efficient work in a number of infested woodlands.

### MAINE.

In 1908, 100 Calosoma larvæ were shipped by express to Capt. E. E. Philbrook, Portland, Me. They were packed separately in glass tubes with earth and liberated by him in Kittery and Wells. Subsequent examinations have shown that the places selected for making liberations were not particularly suitable for the purpose, as the infestations were so scattering that a sufficient quantity of food was not available for the development of the larvæ. In 1913 scouting and liberation of colonies was done by employees of the Maine Department of Agriculture working in cooperation with the Bureau of Entomology.

Colonies were liberated by the above organization in 1914, but we have no records as to the localities.

*Alfred.*—Examinations in this town in 1914 showed the beetles to be present in three localities in the central part of the town.

*Berwick.*—Larval molt skins were found in three localities in the central and southeastern part of the town in 1914.

*Biddeford.*—Beetles were recovered in three well-separated localities in 1914.

*Dayton.*—Larval molt skins were found in the north-central part of the town in 1914.

*Eliot.*—A few beetle larvæ were found here in 1913, and in 1914 they had become common in all parts of the town.

*Kennebunk.*—In 1914 beetles were reported from two localities in this town.

*Kennebunkport.*—The gipsy-moth infestation was rather light in this town in 1914, but beetles were found in one locality.

*Kittery.*—In 1908, 140 beetle larvæ were liberated in three different localities in this town. Scouting was done in 1913 and molt skins were recovered. During 1914 they had spread to all sections and were increasing extensively.

*Lyman.*—Larval molt skins were found in two localities during 1914.

*North Berwick.*—In 1914 as a result of scouting larval molt skins were found in two localities in the eastern part and two in the northern part of the town.

*Portland.*—During 1913, 27 beetles were liberated in woodland near St. Joseph's Academy. They were recovered in the city in 1914.

*Saco.*—Larval molt skins were found in one locality in the central part of the town in 1914.

*Sanford.*—In 1914 beetles were found to be present in four widely separated localities.

*Shapleigh.*—Examinations here in 1914 showed that the beetles were present in three localities.

*South Berwick.*—Beetle larvæ were found quite abundant in all the areas infested by gipsy moths in 1914.

*Wells.*—In 1908, 30 beetle larvæ were liberated in this town. In 1914 larval molt skins were recovered in five widely separated localities.

*York.*—During 1908, 30 beetle larvæ were liberated in the town and 127 adults were colonized in another locality in 1913. In 1914 beetles were recovered in several localities throughout.

RHODE ISLAND.

*Cumberland.*—In 1913, 200 beetle larvæ were liberated in a gipsy-moth infested woodland near Diamond Hill Reservoir. They were recovered in and around the colony in 1914.

*Newport.*—During 1914, 110 beetles were liberated in woodland on Miantonomi Hill.

*Providence.*—In 1913, 170 beetles were liberated in this city; 85 in infested willows off Kay Street, and 85 in Davis Park. They were recovered in and at some distance from the colonies during 1914.

CONNECTICUT.

*Stonington.*—In 1914, 220 beetles were liberated in this town in two localities where *Malacosoma americana* were very abundant, and gipsy moths had been present.

*Thompson.*—No liberations were made here, but beetles were found in small numbers in 1914 as a result of spread from Massachusetts towns.

## ECONOMIC IMPORTANCE OF CALOSOMA SYCOPHANTA.

This insect has now become firmly established in New England. It is reproducing satisfactorily and has already demonstrated that it is a very important factor in the control of the gipsy moth by natural enemies. The beetle is now abundant enough so that it is frequently seen by many residents of the territory where it was first liberated, and a large number of people are familiar with its habits and methods of destroying the gipsy moth. There are a number of very strong

points which increase the usefulness of this insect. The life history of the beetles and the larvæ corresponds very closely to that of the larval and pupal stages of the gipsy moth, so that they are especially adapted to attack this pest. The climbing habits of the Calosoma larvæ enable these creatures to obtain food upon the trees and in this way an opportunity is furnished for the species to increase in large numbers. The fact that the adults commonly live 2 or 3 years, and sometimes 4 years or more, makes it possible for the species to survive under unfavorable conditions. The chances for the species to exist are further increased by the fact that reproduction by the same individuals may occur on alternate years. The species is capable of existing for long periods without food, and passes through hibernation very successfully under New England climatic conditions. All these factors make it an excellent addition to our fauna, and from the results which have been secured from experimental records and in the field it appears that the species at present ranks first among the introduced natural enemies of the gipsy moth. During the summer of 1914 a large amount of field data was secured to determine the relative importance of the different natural enemies of this insect. The results of 1914 indicate that the Calosoma beetle was the most important single factor. The insect continues to spread each year, and in all probability will soon be present throughout the entire territory where the gipsy moth is known to exist. There is no good reason to suppose that it may not spread in small numbers to places outside this territory if sufficient and proper food can be found.

Beetles sent to New Brunswick, Canada, survived the winter satisfactorily, and the same is true of specimens forwarded to New Mexico, which indicates that the insect is able to survive under quite different climatic conditions.

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